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ILLINOIS STATE ACADEMY OF SCIENCE

VOLUME 52 - 1959 Nos. 1 and 2

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William G. Stratton, *Governor*

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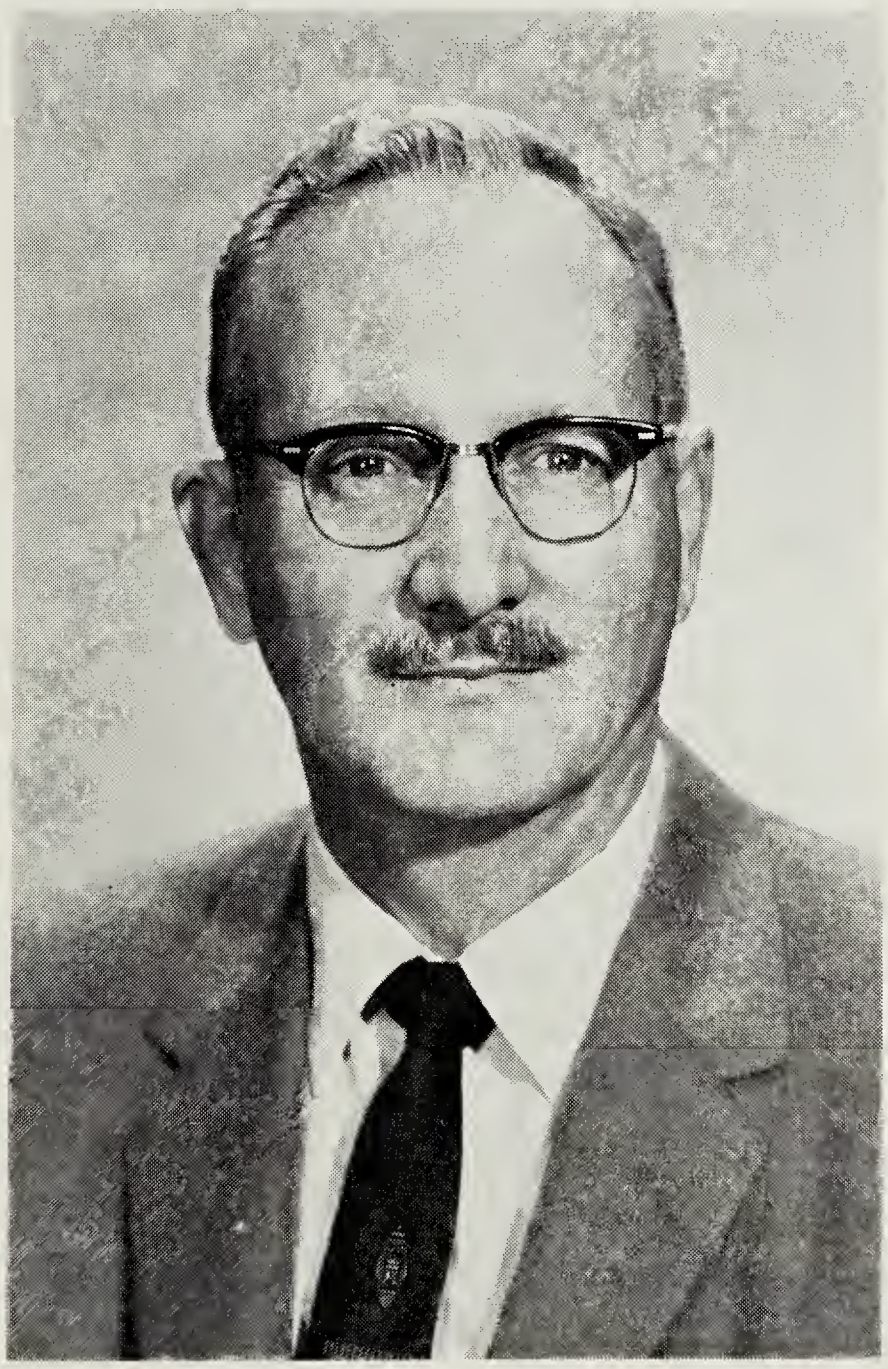
PRESIDENTIAL ADDRESS

THE IMPORTANCE OF BEING NOURISHED

HARLOW B. MILLS
State Natural History Survey, Urbana



HARLOW B. MILLS, *President*, 1958-59

Those of us who have been fortunate enough to raise children will recall that day to day progress in their development is almost impossible to discern. Even at monthly intervals we may have difficulty in noting change. But if we see someone else's youngster after a period of a year, the changes will be obvious. Changes in an old college classmate whom we may meet after 30 years may shock us. So it is with many things about us. Small increments of change which we see regularly may pass almost unnoticed, but large changes may startle us.

Today I should like to discuss some things that are sneaking upon us insidiously, and which we take for granted whether they are for good or bad. The first has to do with numbers of people and their needs and wants; the second has to do with the fulfillment of these necessities; and finally I should like to talk about our responsibilities in these matters.

But before we get into these considerations, let us generalize for the moment.

A long while ago an English preacher by the name of T. R. Malthus stated that human populations tend to be controlled by the food supply. There are those who believe that the old theorist was wrong, but in our western civilization we have not as yet tried out his idea.

We are constantly thrilled and chilled by the great advances made in the physical sciences in the past few decades. The theoretical energy contained in the atom has been brought out of the ivory halls, and the ivory crania of a few philosophers. This theory turned out to be intensely practical, and it was unveiled to the world most dramatically. It was analogous to jumping into an icy lake.

But quietly, without fanfare, and forming scarely a ripple in the stream of consciousness of the most of us, another scientific miracle has occurred. We have temporarily kicked Malthus down into the cellar. We have developed food-producing methods which are the real phenomena of the age, for we can live without our own brand of atom fission but we cannot live without food. We have done a stupendous, a gigantic thing which is without precedent. We have, in my lifetime, doubled our populations and at the same time greatly increased our standard of living. And this, I repeat, has caused scarcely a murmur among the populace; we have taken to it as naturally as we take breaths of air.

Possibly because this achievement sneaked in the back door unnoticed, we find that there are those who feel that it was a natural thing, that it can go on indefinitely, and that there will be no problems in the future; that we can support an almost unlimited number of people on the earth. And this has given rise to two groups with opposite points of view, the "Dangerous Optimists" and the "Fearful Pessimists": those who sing "Hallelujah," and those who cry "Doom."

It is interesting to note that a generalization can be made concerning these two groups. The optimists seem generally to be the production scientists, the applied scientists, and the trusting laymen. The pessimists seem generally to be the more basic scientists, often basic biologists.

In this connection we must not pass without a comment on the place of science in human affairs. The general public, seeing only end results of scientific activity, tends to feel that science has no limits, that there are no problems which it cannot solve. We must remember that too much faith can be put in our powers. We must remember that there is somewhere a limit to our abilities and our production. We must have the humility to remember that we cannot solve all human ills.

People. First let us talk about

people. As a race we have been on the earth for from a half-million to two million years. For hundreds of thousands of these years people skulked around in odd places, grabbing when the opportunity afforded itself and being grabbed when at a disadvantage. The important thing is that humans did survive, and that they held their own and moved about here and there, not diminishing in numbers although not increasing rapidly.

Through all of the history of the human race but the immediate past, growth in numbers must have been slow. In an issue of *Science* of about two years ago, Woodbury says, "The world population is estimated to have doubled from 100 million to 200 million in the first 1000 years A.D., more than doubled from 500 million to 1200 million in the 200 years from 1650 to 1850, and again doubled from 1200 million to 2400 million in the century from 1850 to 1950." If we come to relatively modern times we have some fair census figures:

WORLD POPULATIONS

Year	*Millions*		*Annual increase*
1650	470		
1800	870	5.1X in	2.7
1900	1,600	300 years	7.3
1950	2,400		16.0
2000	3,600		24.0

Ralph W. Phillips, in a recent issue of *The Scientific Monthly,* dramatizes this increase by visualizing a dining table at which two linear feet are given to each person. To seat all people at once would require a table extending around the earth 20 times, with a small auxiliary table only 4,232 miles long. In addition it would be necessary to employ a crew of workmen who would be making tables at the rate of 17.8 miles a day. By 1960, says Mr. Phillips, we would need 21 tables extending around the earth, plus a long auxiliary one 18,500 miles in length.

Now let's see how Paul Sears looks at this question. In his article titled, "The Inexorable Problem of Space," in a recent issue of *Science,* he says that at the present rate of increase in about 22 generations, if we allow a spot 2 by 3 feet per person, there will be standing room only. This would, in 22 generations, put 4,646,400 people on a section of land, about as many people as were living in Massachusetts in 1950. Sears admits that he has allowed plenty of space per person, but believes that each should have enough so that he could reach into his pocket for the rent money.

To digress a moment, A. B. Guthrie recently has quoted Thomas Jefferson as stating that the limit of endurance of people was at a density of 10 per square mile. Beyond this density, Jefferson says people become uneasy, too much compressed, and emigrate in large numbers to new and unoccupied country. As early as 1787 in his *Notes on Virginia,* he expresses concern over population pressures. He assumes a population of 4,500,000 as a competent population for the state. It must be remembered that at that time Virginia extended west as far as the Mississippi River, and contained 121,525 square miles instead of the 40,815 now within its borders. This average of a possible 37 people per section must have concerned him, for he writes, "Yet

I am persuaded it is a greater number than the country spoken of, considering how much inarable land it contains, can cloath and feed, without a matieral change in the quality of their diet.'' Had anyone been able to tell him in 1787 that the population density of that part of Virginia with which he was intimately familar would by 1950 be 81 people per section, surely he would have been much more concerned.

Let us return now from our trip to Virginia. The soil scientist, Firman Bear, says that under pristine conditions there were about 2,400 acres for each American Indian. At the time of Benjamin Franklin's birth there were still about 1,900 acres for each person in the United States. By 1800 this had reduced to a per capita allotment of 400 acres, and by 1900 to 25 acres. In 1955 there were 12 acres per person, and, if there are 300 million people in the year 2000, this will be cut to 6. Now, if you consider that only about one acre in five is tillable, this leaves as of today less than three arable acres for each of us.

Let us see what has happened in the United States since 1800:

United States Population

Year	*Millions*		*Annual increase*
1800	5.3		
1850	23.2	28.5X in 150 years	0.36
1900	76.0		1.06
1950	150.7		1.5
1957	173.0		2.8

When we consider these figures we see all of the symptoms of a species of animal which is in irruption, which has got out of control, and which shows no signs of slowing down. In natural populations we consider this to be a danger sign, a forerunner of a depression in numbers, a break from a peak. If these figures are plotted we get a curve which is not a normal growth curve, but one which shows a startling upsurgence in numbers. Certainly it cannot be considered to be evidence of a normal, healthy, ongoing population.

Food. Earlier we made some strong statements about our growing food production. This growth is entirely due to scientific advancement. The numbers of Americans employed in agriculture have constantly decreased as food production has skyrocketed. In 1850 a farmer fed 5 people, in 1925 he fed 9, in 1950 he fed 15, and in 1955 he fed 20. At the same time the acreage under control of each farmer has increased. Greater efficiency, modern methods, have brought this about. We are no longer an agrarian culture. Farming nowadays might be said to be the field manufacturing of foodstuffs.

How did this come about?

Many scientific advancements contributed to the phenomenon. Hybrid crops produce much more on an acre than did the old open pollinated varieties. One hundred bushels of corn to the acre is now commonplace in the corn belt. New crops and new varieties of old crops have been put to use. More commercial fertilizer is now being used than ever before. Pest control has become a major science. Weed killers eliminate costly farming operations and cut down competition. New fungicides increase yields. Plant breeders have produced many varieties which are resistant to diseases and insects: sugar beets which do not get curly

top; wheat resistant to Hessian flies and wheat stem sawflies; wheat varieties which can withstand the deadly stem rust; apples resistant to scab disease; all of these things are in use or are being perfected. New insecticides so numerous and effective that they startle us are in use today. And well they might. Without them there would be little commercial potato harvest. Our own studies of abandoned peach and apple orchards show that without the use of insecticides and fungicides we would harvest only about 0.2% of the crop. By modern standards untreated fruit crops will yield only one marketable fruit in 500. Dr. G. C. Decker, on the basis of data from the United States Department of Agriculture, estimates that since the advent of DDT and its congeners, the yield of potatoes has risen 160%, onions 140%, sweet corn 160%, tobacco 125%, beet seed 180%, and alfalfa seed 160% (in the state of Washington alfalfa seed increased 420%).

Marketing has made tremendous advances. Take refrigeration and its contribution to keeping foods available throughout the season even though they may be produced seasonally. Grading has forced the production of quality products. Distribution systems have been developed to a high degree. Stored products can be protected from pests which cause deterioration.

All of these things have added to our use of food products made available through modern agriculture.

Furthermore, we are not generally using all of the tools which science has made available to us. The fertilizer industry calculates that if we used proven methods of fertilizing crops, methods tried but not in use, we could keep the present production of corn, cotton, wheat, and hay, and retire 42 millions of acres. Osborn has said that the application of new techniques has, in the 13 years prior to 1953, resulted in a gain the equivalent of production from 64,000,000 acres of land. In Illinois the corn yields for the past ten years have averaged 60% greater than before modern technology took hold.

Nor have we reached the end of this agricultural advance. Many advances are yet to be put into general use and many more are yet to be discovered.

This combination of scientific advance has put us in the anomalous and illogical position of producing foods in such quantities that we can neither eat nor sell them.

The Dilemma. What, then, are we faced with in the future? We are in the midst of a tremendous race, a race between people and their food supply. Populations are growing apace. The rate of increase in the United States is greater than the rate in India. Food production, where modern science has had time and the opportunity to work on it, has grown almost beyond belief.

But man must never overtake his ability to feed himself. And here scientists, and especially biologists, and among them especially biologists interested in population dynamics, have feelings of uneasiness. To carry the belief of the optimists to an ultimate and absurd conclusion, there is no limit to what people can do in feeding themselves! There is a limit, at least when we consider

conventional methods of producing food. And that is where the biologist gets concerned. Theoretically the ability of any successful organism to reproduce itself is infinite. The ability to produce food does have limits, though. It is the finite factor. On purely theoretical bases people *will* overcome their ability to think themselves into a square meal.

The June, 1958, number of the *Kiwanis Magazine* carries a thought-provoking article by Rear Admiral H. G. Rickover. Among many sobering comments we find the following:

"Ominous, too, is the fact that while world food production increased nine percent in the six years from 1945-51, world population increased by 12 percent. Not only is world population increasing faster than world food production, but increases in food production tend to occur in the already well-fed, high-energy countries rather than in the undernourished low-energy countries where food is most lacking."

Let us look at some of the finite factors in food production.

The production of food is dependent on the surface of the earth. Directly or indirectly, we get our nourishment from that surface upon which the sun shines. But we must be more specific. There are approximately 196,836,000 square miles of surface, according to Phillips. Of this, only 55,786,000 square miles are land, the remaining are water; only 28.3% of the earth's surface is land. Twenty percent of this area is in permafrost. More than 20% is too rough or too high for permanent human habitation. Another 20% is too arid for cultivation. That leaves us with less than 40% of the land surface to play around with in producing food.

Of the land available, we are losing area from production. Despite the greatest and most widespread interest in soil conservation ever known, we are still losing topsoil through careless handling. Further, we submit to what I call land usurpation. This is a rather new thing as an effective agent in reducing the food production potential, for until the last half-century we have been adding more acres than we have been subtracting. According to Ordway, farm, forest, and grazing land in the United States was reduced by 16,000,000 acres from 1935 to 1945. This went into the building of cities, industrial development, roads, highways, and the like. Kennard points to the Miami Valley in Ohio. Twenty-five years ago it was a rich, productive farming area. Now, particularly from Springfield to Cincinnati, this is an industrial area. There are those that believe that a strip from Milwaukee to Peoria will, before long, be completely usurped for residence and industry. When this happens St. Louis will grow north up the Illinois and the two urban areas will be joined.

From 1942 to 1956, on a nationwide basis, 20,000,000 acres have been withdrawn from food production. This is 5% of the total cultivatable acres in the United States.

The Department of Agriculture estimates that each year we are losing 1,250,000 acres of good farmland. From 1942 to 1957 Ohio, Indiana, Georgia, Florida, and Texas each lost about a million acres. Connecticut has lost one-third of its cul-

tivatable land, and it is estimated that another ten years at the present rate of usurpation will see the last of that state's good, commercial, producing farmland.

The optimists say that we can irrigate new lands. Testimony given by the United States Department of Agriculture before Congress in 1952, according to Osborn, indicates that the food and export needs of the country by 1975 will require 113,000,000 more acres than are now being farmed, and this is 70,000,000 more acres than are planned on by the government in all of its land development and reclamation projects.

The tropics have always held an attraction to the optimists. All we have to do is to clear the Amazon basin and start to produce food and transplant people there. So far this has not worked. In a stimulating new book on the tropics by three Frenchmen, de la Rüe, Bourlière, and Harroy, there are some sobering comments: "The legend of the inexhaustible fertility of the soil in the hot countries has taken a long time to kill," they say. "Too many fantastic accounts have given rise to a strongly held opinion that the surfaces cleared of the great tropical forests are of an unheard-of richness.

It has now been convincingly shown that, generally speaking, the soils of the tropics have nothing like the fertility of those of temperate regions, that their yield under cultivation is in general less, and that they are also very easily destroyed."

And so it goes through the most of the proposals of the optimists.

Let us quote some pertinent comment from a couple of the thinkers of the day.

In a speech given by Dr. Milton Eisenhower, we find the following: "If we had at this moment a feasible 25-year plan to bring the diet of people everywhere up to about 2600 calories per person per day (a meager diet by your standard and mine)—if we had such a plan, I say, it would involve increasing world food production by 110 percent, taking into account the estimated increase in population. And I say in all earnestness that it is an open question whether food production, for all our science, can be increased by that much."

The University of Chicago's physiologist, A. J. Carlson, discusses the effect of modern medicine on the human race, and states that we are increasing the race faster than we are increasing food production. He concludes as follows: "What is the answer to this serious situation? Shall it be less of modern biology and medicine? more starvation? more violence and war? or more intelligence? . . . there is fairly good evidence that we must practically double the present world food production even to feed adequately the present world population. So far as can be judged, this cannot be done."

Well, that is that.

The dilemma in which we find ourselves now is apparent. What can we do with people, and what can we do with food? We are not only watching, we are participating in the greatest race in history—the race between the farmer and the obstetrician!

The Future. Now, what can we as producers of food look forward

to in this struggle?

In the first place, we will have to keep in mind that there is an inverse relationship between the numbers of people and individual freedom. If there were but one person on the earth there would need to be no laws governing the conduct and activity of society. If there were two people then there would have to be certain understandings between them. And so it goes. If we look back we can all list restrictions which have been imposed on us for the good of the whole populace. Grading restrictions affect the quality of those things which we produce. More recently we will recall the Miller Bill, which sets up federal machinery governing the allowable tolerances for pesticides in foodstuffs. To some this has meant a restriction in personal liberty, but it does only to the extent of need in protecting people who use the foods we produce.

Withholding taxes, increases in income taxes, are invasions of our right to earn according to our abilities and penalize the successful, but they seem to be needed in the protection of our citizenry.

I sometimes wonder if the large number of organizations which, although they may be very moral, prey upon the family units are not regimenting both parents and children right out of the family where they belong.

Our work is organized and regimented. Our recreation is regimented. In this country, where there is great freedom of thought and criticism it is probable that our thinking is either purposefully or unconsciously molded into patterns.

As people become more abundant our personal radii of freedom become shorter and shorter. We haven't seen the end of this yet, and curtailments of personal liberties for the good of the whole population, which would now cause us great concern, will in the future be accepted as commonplace.

Some of this will come sooner than we anticipate, too. It is the function of increased numbers of people on the same area. Demographers know that the great increase in births which occurred in the forties will result in a great increase in marriages in the sixties, and a consequent increase in births again. This spells good times for the manufacturers of wedding supplies and baby rattles, but it also means a greater demand for food from the same or a smaller acreage of land. To the food manufacturer or producer this means greater sales of his products, but he would do well to consider this not as an economic boon but rather as a serious responsibility.

Eating is more than nutrition. It is not the mechanical ingestion of 2000 or 2600 calories a day. Man is differentiated from the other animals by his mental abilities, which are expressed in many ways. One is in his appreciation of his environment which may be expressed in the preservation of wilderness, an awareness of the birds of his area, the thrill of a bright sunset, or in a love of good food. He differs from an earthworm in this respect. And we have not as yet heard a corn borer ask for some monosodium glutamate, or a squash bug for nutmeg, or a cow for raisins in her breakfastfood, or a lion for Worchestershire sauce. I

am not implying that every person must become or now is a gourmet. What I am saying is that our standard of living demands more of our food right now than the ability to sustain life, and this makes more demands on food production and food processing.

Another point is worth mentioning. If in some way the population of the United States were to be stabilized at its present level the demand for foodstuffs would also tend to level off, but it would still rise at a considerably lower rate. To level it off completely would mean putting a ceiling on our standard of living as it is now, and it would be difficult to believe that this would occur while we have the ability to increase this standard. Not only is the per-capita use of food increasing, but the channeling of agricultural products into non-food uses is increasing; both of these uses are brought on by our increased living standards. Quality in our foods would not level off with a leveling population; quality demands will continue and will increase with time.

In discussing the future, let us go one step more. If man is to remain man he cannot live by bread alone. While the discussion of food and people may have seemed academic to some of you, it certainly is not in one respect. If we are willing to make the risky assumption that food and appetites will balance for some time to come, *the matter of space in relation to recreation will not*. If more space is needed for living it will be taken for living. If more space is needed for industry and other artifacts of our culture the pressure will be on us for that type of land use. If more land is needed for food production it will be put to that use.

These are sobering contemplations. As populations grow and land surface is more and more usurped, and, possibly long before human hunger strikes us, recreational needs will have to be protected much more assiduously than even now.

When we think of the future of recreational lands in all of this competition for land use, we cannot get away from zoning. We must think of areas where people will live, where they will work, where their roads will go, where they will produce their food, where they can find outdoor relaxation, and where wildlife can live and prosper. We may not like the idea of such regimentation; it will be an expression of restriction of personal freedom due to increased population density.

Perhaps we who are interested in the broad aspects of recreation are a little ahead in this area, for the setting aside of state and national parks, wilderness areas, and the like, certainly are a form of zoning. But for the future, what faces this exploding population? To provide for them we should now be in the business of acquiring land for recreational purposes; now while surpluses are plaguing us; now while there is still an abundance of questionable and submarginal land available; now before other human "needs" have usurped everything with a handle on it. Now is the time to add greatly to our recreational and protective land holdings for the millions who are yet to be born.

We have hardly tapped the store of things which an increasing popu-

lation will demand of us. In fact, we haven't the imagination to pick clean the bones of the future. It is much easier to pick the bones of the past. A newspaper reporter once visited a scientific meeting and covered a report on a new and peculiar fossil with an enlarged ganglionic space at the base of the spine. Rather than the usual press story, he was inspired to the following dozen lines:

"'Tis plain to see from these remains,
This creature had two sets of brains;
One in his head, the usual place,
The other at the spinal base.
Thus he could reason *a priori,*
As well as *a posteriori.*
No problem bothered him a bit,
He made both head and tail of it.
If aught escaped the forward mind
'Twas captured by the one behind.
And when in error he was caught
He had a saving afterthought.

In my attempts to translate an afterthought into a forethought, one thing should be clear to us all. There is an immense problem ahead for all of us who are interested in the well being of our descendants. And this problem carries with it an immense and immediate responsibility.

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HEAVY MINERALS IN THE UNDERCLAY OF THE ILLINOIS NO. 2 COAL

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Introduction

This study was made to determine what heavy minerals were present in the underclay of the Illinois No. 2 Coal. This underclay is of Pennsylvanian age and in Illinois is found in the Liverpool Cyclothem of the Carbondale Group. Illinois No. 2 Coal has been correlated with Indiana IIIa Coal, Kentucky 8a Coal, and Missouri Croweburg Coal.

The subjacent sediment of this underclay varies in lithology throughout the Eastern Interior Basin, but the underclay and its coal are persistent units. At some locations the underclay apparently is transitional into the subjacent sediment, while in others the break between the two sediments is sharp. The thickness of the underclay ranges from 5 inches to 7 feet or more; the average thickness for the 68 localities is approximately 3 feet.

The underclay is typically light gray with a thin, darker, plastic zone a few inches thick at the top. *Stigmaria* are commonly present. Small slickensides can be found throughout, some as much as an inch or two in length. Limonite staining is common along small cracks at many of the clay outcrops.

Review of the Literature

Allen (1932: 565-570) in his study of the mineralogy of the Pennsylvanian underclays of Illinois briefly mentioned four heavy minerals he had identified — muscovite, biotite, epidote, and hornblende. He noted that both the epidote and hornblende were altering to clay minerals from the outside inward and that the percentage of biotite and heavy minerals was more closely related to texture than to the depth below the coal. He believed that this percentage-texture relationship was controlled by conditions of deposition rather than of weathering.

Grim and Allen (1938: 1496, 1502) in their work on the petrology of the Pennsylvanian underclays of Illinois found that heavy minerals constitute a very small part of the underclays. They recognized muscovite, biotite, pyrite, zircon, tourmaline, rutile, garnet, apatite, barite, glauconite (?), epidote, hornblende, and chloritic mica, the last probably derived from the decomposition of biotite. They found that some grains of epidote and hornblende had been altered along their edges and along cracks, but that others showed no alteration.

Spencer (1955) made a petrographic study of the underclay of Illinois No. 6 coal. The principal heavy minerals found were zircon, tourmaline, leucoxene, and rutile; muscovite, chlorite, pyrite, hornblende, and garnet also were found in smaller amounts. This stable heavy-mineral assemblage suggested to Spencer that the materials composing the underclay were derived from pre-existing sediments. Both well-

rounded and euhedral tourmaline crystals were found in the underclay, and Spencer suggested that the euhedral variety had formed authigenically. Zoned zircons were present, as were well-rounded and euhedral varieties. Rutile varied from well-formed elbow twins to well-rounded grains. The twinned variety showed no signs of wear and was thought to be authigenic. Pyrite was more prevalent in the upper than in the lower portions of the underclay sections.

Wahl (1957), who made a petrographic study of the underclay of Illinois No. 5 Coal, found that pyrite, tourmaline, and zircon were the most common heavy minerals present but that the suite included garnet, leucoxene, hypersthene, chlorite, and muscovite. All the tourmaline crystals he observed were elongate and euhedral, and he too believed that the tourmaline had formed authigenically. The zircon occurred both as elongate, doubly terminated crystals and as well-rounded grains. The garnet showed little rounding.

Sampling Procedure

In the course of my study, 87 samples of the underclay of Illinois No. 2 Coal were collected from outcrops and diamond-drill cores in Illinois, Indiana, Kentucky, and Missouri. The samples represent 68 locations throughout the Eastern Interior Basin (Fig. 1). The sampled area has a maximum north-south distance of 360 miles and a maximum east-west distance of 240 miles.

Each underclay outcrop or core was examined to determine whether there were any apparent lithological changes in the section. If changes were noted, the various lithologies were sampled separately. Throughout the remainder of the study, these samples were treated separately in all analytical procedures. Channel samples were obtained from all outcrops, and chips were taken at about one-inch intervals from the diamond-drill cores.

Method of Analysis

Approximately 100 grams of each sample were allowed to disaggregate in water for at least 4 days. The sample was then mixed by an electric handmixer and allowed to settle for 20 minutes. At the end of this time, the material in suspension was decanted and the sample was remixed. This procedure was continued until the sample appeared to be free from suspended material at the end of a 20-minute period. The remainder of the sample was then washed into a 500-micron sieve and the minus 500-micron fraction was dried. About 7 grams of this fraction was placed in a 125-ml. separatory funnel with approximately 25 ml. of the heavy liquid bromoform (sp. grav. 2.85). The sample was stirred thoroughly in the funnel and allowed to settle for 24 hours. Occasionally during the 24-hour period the separatory funnels were agitated slightly to release any adhering particles from the sides of the funnel. After 24 hours the heavy minerals were removed, washed with acetone, and dried on filter paper.

The heavy minerals were mounted on slides that had been covered with a thin coating of balsam thinned with xylol. The coating was thin enough

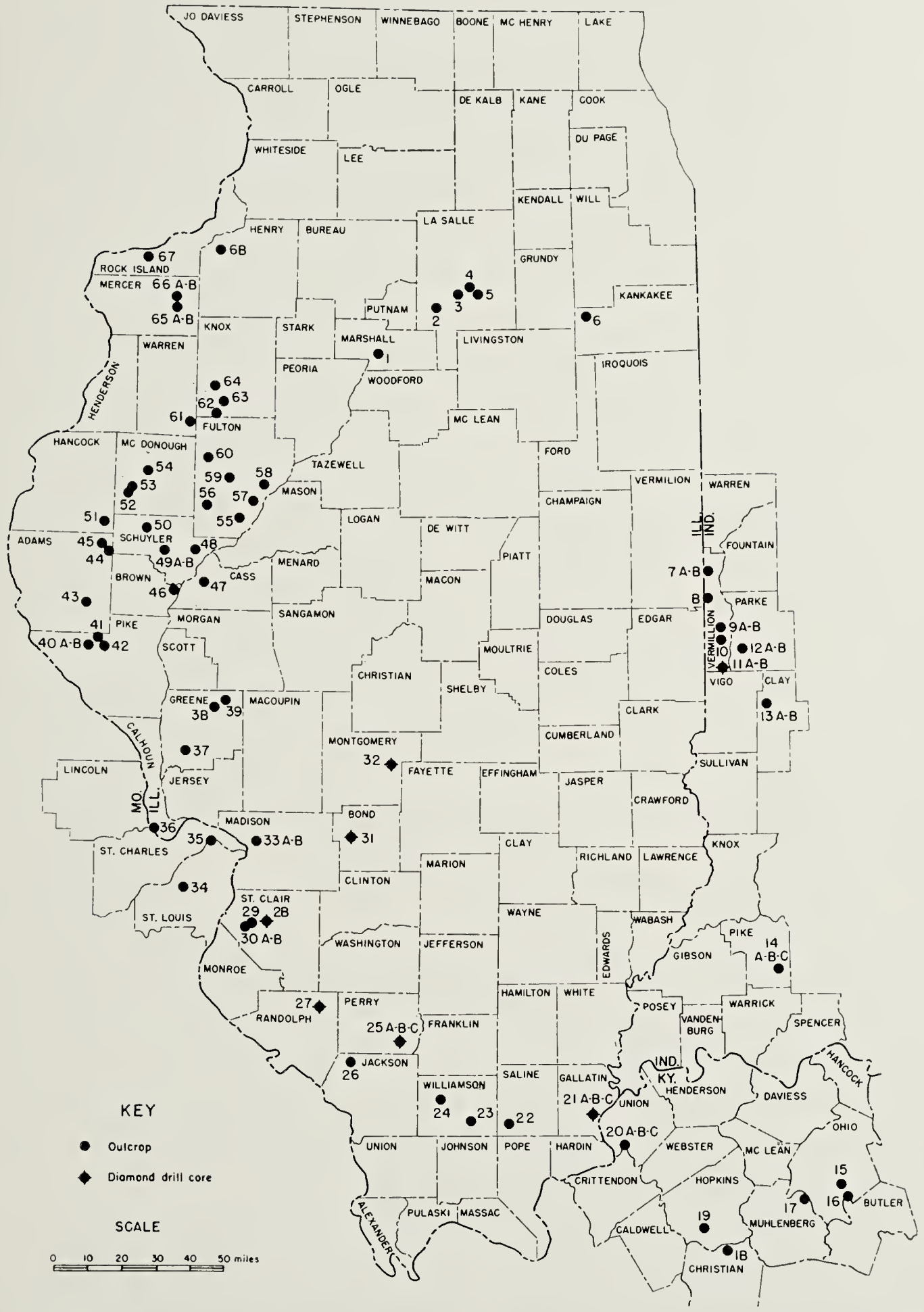


FIG. 1.—Locations of samples of the underclay of the Illinois No. 2 Coal.

so that when the heavy minerals were spread over the soft balsam their surfaces were not completely covered, thus making possible the use of oils in the determination of the mineral indices. The slides were then allowed to dry before further use.

Discussion

The minus 500-micron fraction of heavy minerals of each sample was mounted as described and studied with a petrographic microscope.

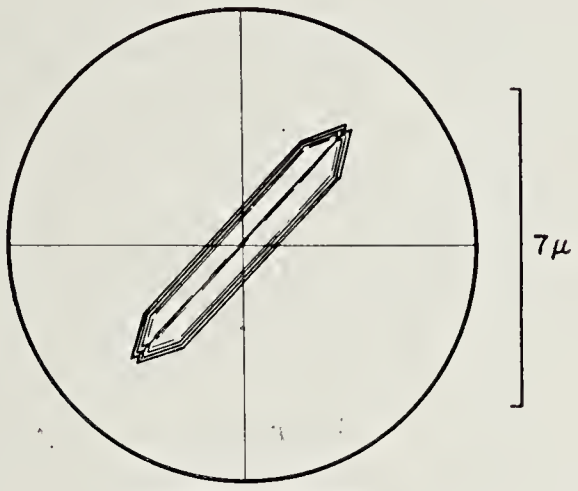
Muscovite is present in 92% of the samples. Its size and outline generally are irregular, although in a few instances a faint hexagonal outline can be distinguished. Some of the flakes appear to be very thick. All of the muscovite observed was colorless.

Pyrite is present in 73% of the samples. It appears in six forms—striated cubes, octahedrons, pyritohedrons, spherulites, irregular masses, and tiny rootlets and plant structures. While the heavy minerals were being separated, a record was kept of the relative amount of pyrite in each sample; in most cases there is more pyrite in the finer grained underclay than in the coarser underclay. The well developed crystal forms of the pyrite show it to be authigenic. (Authigenic minerals are those that have formed independently in sedimentary rocks and are not to be confused with overgrowths that have formed on pre-existing minerals). The pyrite owes its origin to a reduction of iron salts by organic compounds. In many of the more weathered outcrops, the pyrite has been altered to limonite.

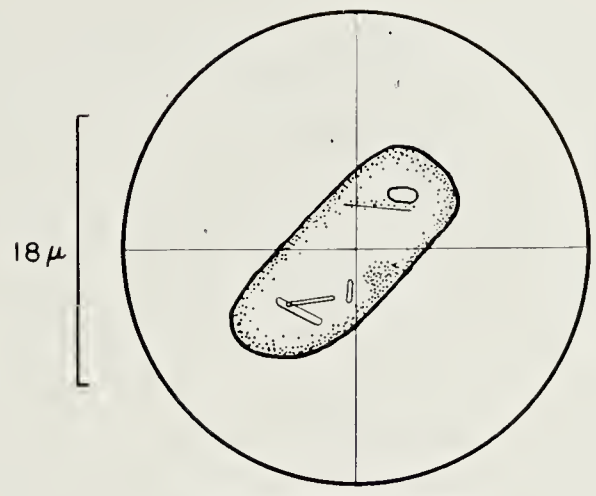
Zircon is present in 72% of the samples. Most of the crystals are simple combinations of prism and pyramid; all are colorless, and zoning is common in many crystals. Doubly terminated zircons are abundant and average about 7 to 10 microns in length. These crystals could be either authigenic or detrital as their small size and extreme hardness of 7.5 would have allowed them to be transported a considerable distance without showing evidence of wear. Well-rounded zircons are found in the presence of euhedral zircons. If some of the zircons have formed authigenically, the presence of overgrowths on other zircons would be expected. No overgrowths were noted. As zircon is an accessory mineral in almost all classes of igneous rocks, the well rounded examples may have been derived from reworked pre-existing sediments.

Tourmaline is present in 67% of the samples. It appears as irregular fragments, well-rounded grains, euhedral crystals, and as overgrowths on other well-worn or fragmental tourmaline grains. In many instances, the euhedral crystals are hemimorphic, *i.e.*, they display different forms at opposite ends of the crystal (Fig. 2). Varieties of tourmaline found in this underclay are brown, tan, olive-drab, pink, or colorless.

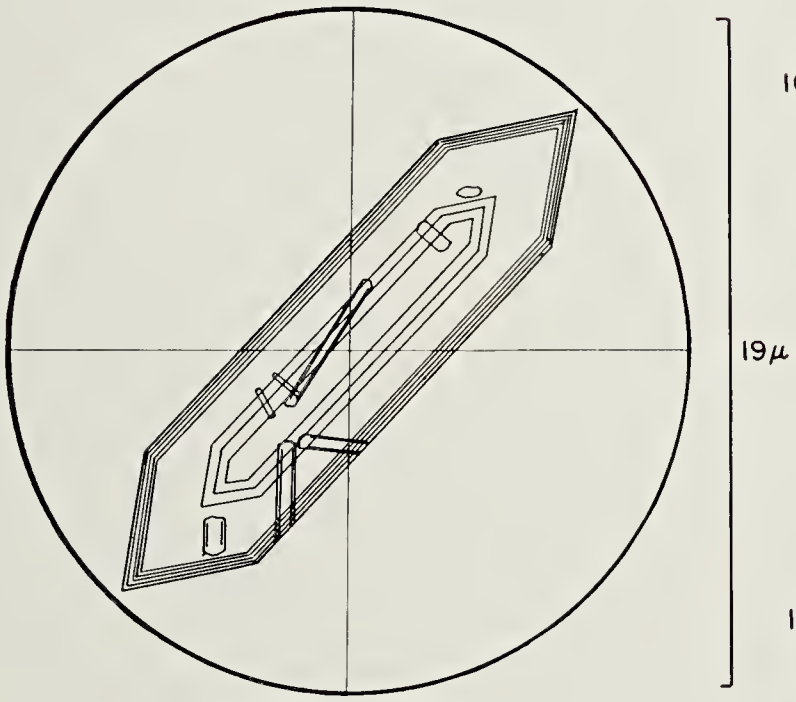
Most of the irregular fragments probably were derived from an iron-rich source as they are darker and have deeper pleochroic colors than do the euhedral varieties. In general, the euhedral crystals are pink and do not display strong pleochroic colors. The pleochroic color of the overgrowths generally is lighter than that of the covered older grain.



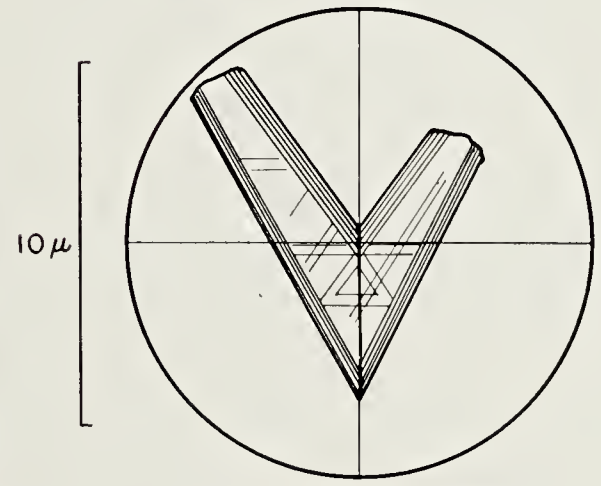
TWINNED ZIRCON



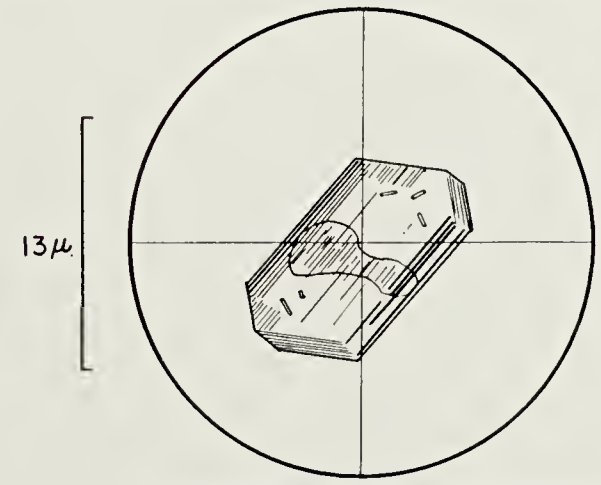
WELL ROUNDED ZIRCON



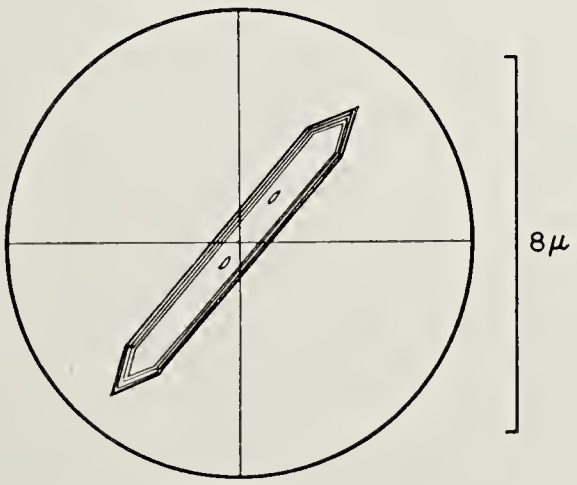
ZONED ZIRCON



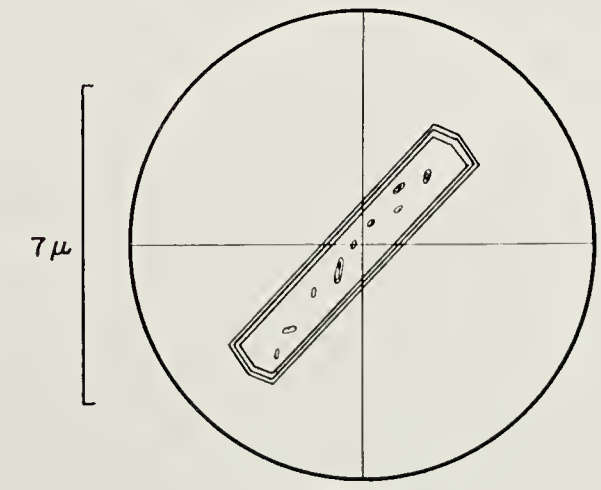
RUTILE, ELBOW TWIN



TOURMALINE WITH OVERGROWTH



ZIRCON



TOURMALINE

FIG. 2.—Common heavy minerals of the underclay of the Illinois No. 2 Coal.

Spencer (1955) thought that the euhedral varieties of tourmaline had formed authigenically. He stated that the material necessary for the formation of tourmaline, which is a complex boron aluminum silicate, could easily be obtained from the underclay. The boron would be released from decaying plant material, and the aluminum and silicon derived from many of the silicate minerals of the underclay itself. On the other hand, tourmaline is a mineral common in metamorphic and acid dike rocks and the euhedral tourmaline as well as the well rounded and fragmental pieces could have been derived from either source and, like euhedral zircon, may have undergone transportation without showing wear because of its hardness (7 to 7.5) and extremely small size (7 to 8 microns).

Krynine (1946) listed the "resistance coefficient to abrasion" of various minerals, compared with tourmaline, as follows: tourmaline, 850-900; chalcedony, 510; quartz, 245; and orthoclase, 150. It is apparent that tourmaline can undergo considerable transportation and abrasion and yet show very little wear in comparison with these other resistant materials. The well-developed crystal form of those grains possessing overgrowths tends to support Spencer (1955) in his belief that some of the tourmaline overgrowths formed in place in the underclay whereas other tourmaline was transported from other areas. The rounded forms apparently have undergone many cycles of erosion.

Limonite is present in 62% of the samples and is found as coatings on grains and as irregular, resinous, rounded masses. It is probably produced by the weathering of pyrite. In many instances it coats and stains other minerals, sometimes completely masking them. Only a few heavy mineral samples were treated with acid to remove the iron present.

Rutile is present in 43% of the samples. Generally, it appears as irregular, broken fragments, or as elbow twins. It is rusty red in color and commonly occurs in igneous and metamorphic rocks. Almost all grains or crystals observed show some signs of wear.

Ilmenite is present in 10% of the samples. It appears as black, irregular, pitted grains.

Leucoxene is present in a few samples. These samples were coated with limonite and had to be treated with hydrochloric acid to remove the iron. The leucoxene appears as rounded or oblong grains, dull, grayish-white in color. It may have been formed as a decomposition product of ilmenite.

Chlorite was recognized in one sample by its characteristic Berlin-blue interference color. The crystals were small and irregular in shape.

Much of the unidentifiable mineral present resembled mica flakes of a pale greenish-yellow color and may be the product of a much-weathered biotite. Optical properties could not be determined on these flakes.

Summary and Conclusions

Pettijohn (1957: 516) listed the persistent heavy minerals frequently found in the late Paleozoic sediments as rutile, zircon, tourmaline, garnet, biotite, apatite, ilmenite, magnetite, staurolite, and monazite. My study, like those of Grim and Allen (1938), Spencer (1955), and Wahl (1957),

shows very similar assemblages with only slight variations.

The heavy minerals commonly present in this underclay are muscovite, pyrite, zircon, tourmaline, and rutile, an assemblage of very stable minerals. Some of the well-rounded tourmaline grains show that they must have undergone many cycles of erosion, whereas others show the sharp, euhedral form. The euhedral crystals may be authigenic or may have been transported without showing signs of wear. The extremely small size of the crystals and their great hardness could have protected them from wear during transportation. However, some of the euhedral tourmaline crystals are actually overgrowths on old, well-worn tourmaline grains. Still other euhedral tourmaline grains are definitely not overgrowths, and their euhedral form strongly indicates their authigenic origin. Their optical properties suggest a chemical composition different from that of the rounded and fragmental tourmaline.

A greater percentage of pyrite is found in the finer than in the coarser grained sections. It is authigenic and is found in the form of rootlets, plant structures, and euhedral crystals. This indicates that reducing conditions prevailed during underclay deposition. The circulation was probably poorer in the finer-grained sections, resulting in the higher content of pyrite in these sections today.

The stable heavy minerals and the presence of well worn and fragmental minerals suggest that the underclay was in part a transported sediment. Some of the heavy minerals have undergone many cycles of transportation and deposition.

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GROWTH OF SHORTLEAF PINE THINNED BY CROWN AND ROW METHODS

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Row thinning has certain practical advantages over other methods in the management of forest plantations. These include: 1) lower marking and administrative costs; 2) lower felling costs; and 3) easy access for felling, loading, and hauling. There are some doubts, however, if it is as desirable as the crown method when considered from a silvicultural standpoint (Boggess, 1951; and Boggess and McMillan, 1955).

Thinnings are made to improve stand quality and maintain optimum growth rates. This is accomplished in crown thinning by removing immediately competing trees from a selected number of the most desirable trees in the stand. These latter individuals are commonly known as "crop trees". With each succeeding intermediate cut, crop trees are again selected and released as before. Through this process of selection, trees which make up the final harvest should represent the best trees in the stand. Row thinning does not provide this type of selection, nor are individual trees released on all sides as in a crown thinning.

A study was initiated in the winter of 1954-55 to investigate the following, using the crown and row methods in thinning a shortleaf pine plantation: 1) General stand structure and growth under each method of thinning; 2) Diameter growth of selected trees in plots thinned by crown and row methods, and in unthinned check plots; and 3) Diameter growth of comparable trees from the inside (unreleased) and outside (partially released) rows of row-thinned plots in which every fourth row of trees was removed.

Methods

Six, one-fifth acre plots were established in an 18-year-old shortleaf pine plantation at the Dixon Springs Experiment Station of the University of Illinois (Pope County). Two plots were thinned by removing every fourth row of trees. Two additional plots were crown-thinned by completely releasing 200 or more crop trees per acre. Plots of both thinning treatments were cut to the same residual basal area. Two plots were established as checks.

Weekly growth measurements were made with a dial-gauge microdendrometer thoughout the growing seasons of 1955, 1956, 1957, and 1958. This instrument measures radial changes to the nearest one-thousandth of an inch and is similar to one described and illustrated by Holsoe (1951). It has been used in other studies by Boggess (1957) at the Dixon Springs Station. Microdendrometer growth data are expressed in terms of basal area since all other plot records are kept in this way. Weekly increases (or decreases) were calculated and expressed as the average cumulative growth per tree for a given treatment.

Microdendrometer stations were established on 25 trees on each of the crown-thinned and check plots. Thirty stations were established on each row-thinned plot, 15 of which were in the outside rows and 15 on inside rows. Trees used for microdendrometer measurements were chosen from the crop trees on the crown-thinned plots and from trees of comparable size and vigor on the row-thinned and check plots.

Soil and Site Description

The soil is Grantsburg silt loam, a recently correlated series resembling the Grenada soils which occur from western Kentucky to northeast Mississippi. These are Gray-Brown Podzolic integrated to Red-Yellow Podzolic soils developed under forest vegetation from 80 inches or less of loess deposited over a predominantly sandstone bedrock. Under forest cover (uneroded) the silt loam A_1 horizon, which is two to four inches deep, is underlain by a silt loam A_2 horizon six to eight inches thick and a silty clay loam B horizon. A moderately well-developed silt pan (fragipan) occurs at depths of 30 to 36 inches from the surface. The silt pan is massive in structure, hard, and compact. It affects both the downward movement of water and root penetration.

The site was cultivated and abandoned prior to 1935. It is on a low ridge with a slope of about 4%. Erosion was moderate over the area prior to planting.

Results

The number of trees and basal area per acre, prior to thinning, for each treatment are shown below.

	No. trees/acre (3.6 in. d.b.h. and over)	*Basal area, sq. ft./acre*
Row-thinned	742	140.2
Crown-thinned	732	139.8
Unthinned	810	142.0

Basal area of the thinned plots was reduced to approximately 100 square feet per acre. The residual stand was as follows: 1) Row-thinned—568 trees per acre with an average diameter of 5.8 inches (decrease of 0.1 inch following thinning); and 2) Crown-thinned—488 trees per acre with an average diameter of 6.1 inches (increase of 0.2 inch following thinning).

Growth of all trees during the four growing seasons of 1955-58 was as follows:

	Basal area/acre		*Av.*
	Sq. ft.	*Per cent increase*	*diam. inc., in.*
Row-thinned	25.0	24	0.7
Crown-thinned	27.0	27	1.0
Unthinned	20.3	14	0.4

Growth of trees selected for microdendrometer measurements is shown in Figs. 1, 2, 3, and 4 for each of the four growing seasons. Data for the outside and inside rows of the row-thinned plots are plotted separately. The combined growth of these two groups lies approximately midway between these two curves. Growth data for unthinned trees is almost identical to that of the unreleased rows on row-thinned plots and, for the sake of clarity, are not shown on the figures.

Discussion

More large trees were removed in the row thinning than in the crown

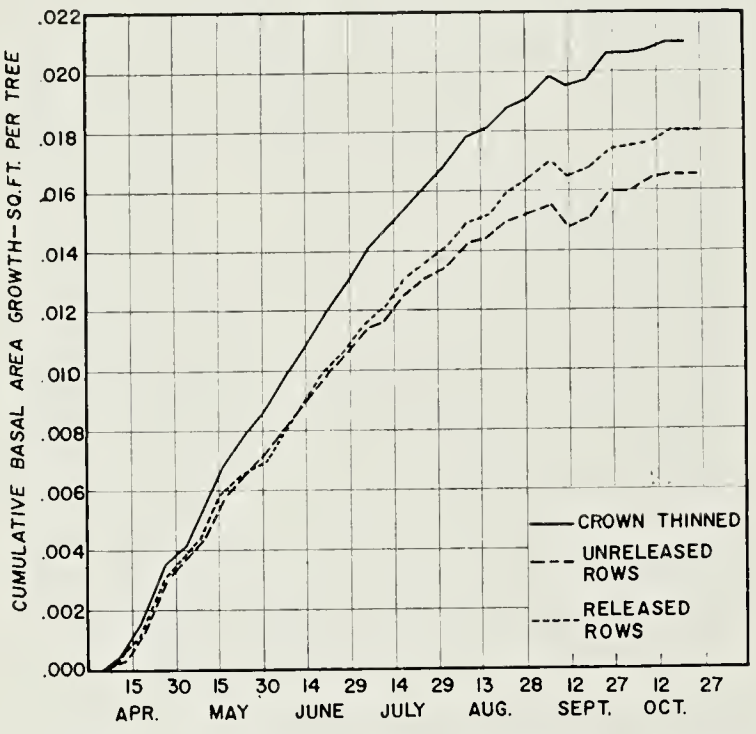

FIG. 1.—Basal area increase during 1955 growing season.

thinning. This may not seem to follow the concept of the latter method where cutting is usually heaviest in the dominant and co-dominant crown classes. By definition, however, the crown method provides for the removal of poor quality trees, or those which may not live until the next thinning, regardless of crown class. In this particular case many trees, damaged by the severe glaze storm of January, 1952 (Boggess and McMillan, 1954), were salvaged in the crown thinning. This could not be done on plots thinned by the row method.

Basal area growth during the four-year period was slightly better on crown-thinned than on row-thinned plots, while growth under both thinning treatments exceeded that of the unthinned check plots. Diameter increases were of the same order.

The growth difference between the two thinning treatments was only two square feet of basal area per acre. This, alone, is not enough to warrant the use of the crown method if possible savings in administration and operation should favor use of the row method. However, over-all growth does not tell the complete story. The selected trees in the crown thinning grew more than comparable trees in the row thinning (Figs. 1-4). This is directly related to the degree of release, which ranged from all four sides in the crown thinning to release on one side only in the outside rows, and no release for trees in the inside rows of the row thinning.

The released trees in the crown thinning were provided ample growing space and their crowns expanded in all directions, thus developing a much greater leaf surface. In the released rows of the row thinning, space for crown expansion was provided only on one side. Trees in the unreleased rows apparently did not benefit from the thinning as they did not grow any more than those on the unthinned check plots. It is generally believed that diameter growth depends largely on the products of current photosynthesis (Kozlowski, 1958). Thus it is logical that, other things being equal, trees having the

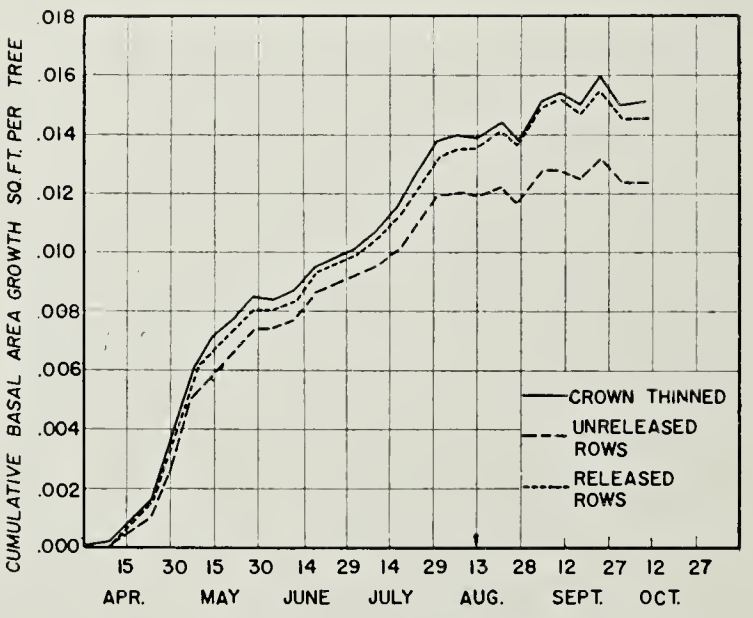

FIG. 2.—Basal area increase during 1956 growing season.

greatest amount of leaf surface would tend to make the greatest diameter growth.

With the foregoing in mind, the growth for 1956 (Fig. 2) should be noted. Two things are apparent when it is compared with the results of the other three years: 1) amount and rate of growth in 1956 were considerably less; and 2) there was very little difference in growth of completely released trees (crown thinning) and partially released trees (row thinning). This is related to the availability of soil moisture, which in turn depends on the amount, intensity, and distribution of rainfall (Boggess, 1957). Precipitation was normal in April, 1956. Deficits of 0.64, 2.47, 1.32, and 1.82 inches occurred in May, June, August, and September, respectively. July had an excess of 2.03 inches, but the amount is deceiving as most of it fell as intense thundershowers

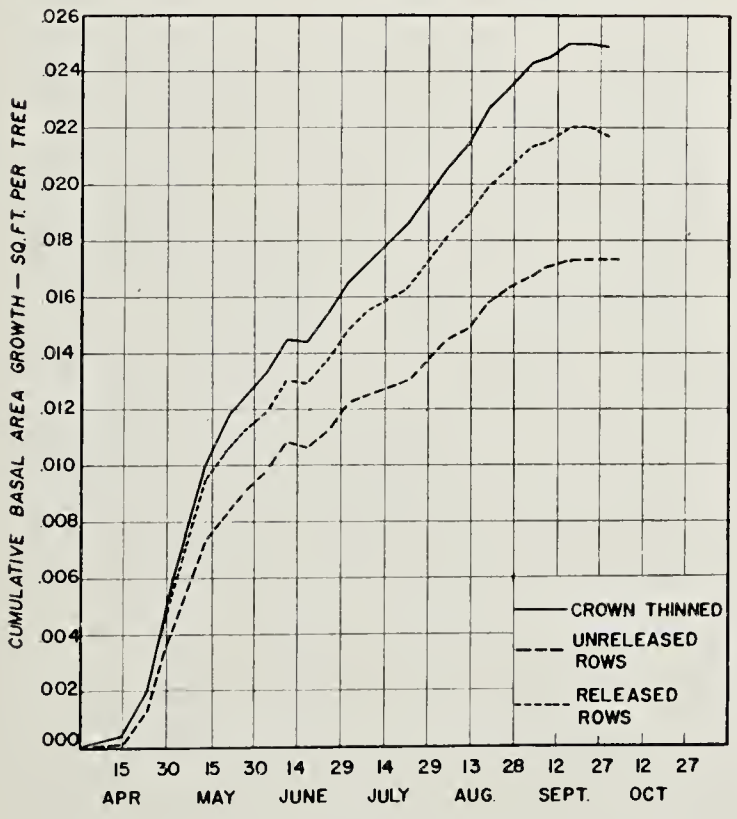

FIG. 3.—Basal area increase during 1957 growing season.

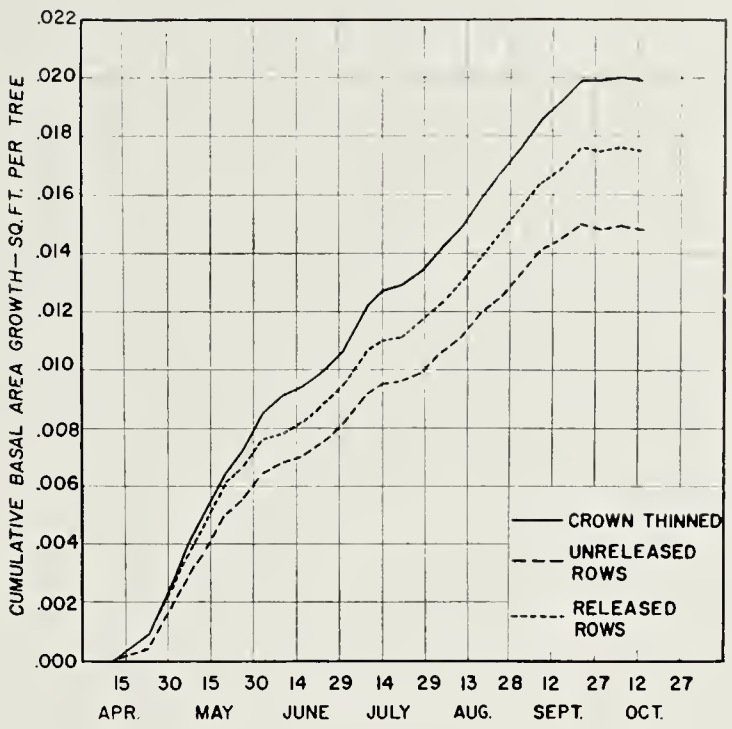

FIG. 4.—Basal area increase during 1958 growing season.

between the 15th and 25th of the month. Soil moisture measurements, taken in a near-by plantation of the same age, indicated that the available moisture was exhausted by the first of August and diameter growth essentially ceased at that time. During the early part of the season, the 1956 growth rate compared favorably with that of the other three years. After June 1 growth slowed, probably as a result of reduced photosynthesis accompanying the rapid depletion of soil moisture (Kozlowski, 1949, 1958). The continuing moisture stress, broken only by the period of high intensity rains in late July, minimized the effect of the increased photosynthetic surface of crown-thinned trees as compared with those in the row thinning. Thus there was little difference in the amount of mid- and late-season growth between the completely released trees in the crown thinning and partially released trees in the row thinning. In other years most

of the growth differences occurred after the middle of May.

In contrast to the above a sharp reduction in diameter growth occurred for a short time in mid-July, 1958, when moisture was excessive. July rainfall was 14.25 inches, with 10.20 inches between July 15 and 22. The rate of photosynthesis was probably reduced during this period. Loustalot (1945) found flooding of pecan trees, growing on a sandy soil, caused photosynthesis to drop to 11% of the normal rate with even greater reductions occurring on heavier soils. While the soil in this instance was not actually flooded in the sense of having standing water on the surface, it was completely waterlogged.

Summary

1. The diameter of selected trees from plots which had been thinned by crown and row methods, as well as those from unthinned check plots, were measured weekly with a dial-gauge microdendrometer during the growing seasons of 1955, 1956, 1957, and 1958. In addition, all trees were measured at the end of each growing season.

2. Diameter growth was related to the degree of release. Trees released on all sides by crown thinning grew more than those released on one side (in the outside rows of the row thinning), while trees in the inside rows grew at about the same rate as those on unthinned check plots.

3. Total basal area growth during the four-year period was slightly better on crown-thinned than on row-thinned plots, while growth under both thinning treatments was considerably more than that of unthinned check plots.

4. The relation between diameter growth and soil moisture is discussed.

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FISHES OF KINKAID CREEK, ILLINOIS

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The primary objective of this study was to determine the species composition of the fishes of Kincaid Creek and its possible potential as a fisheries resource. The ecology of the fishes was in part determined by a study of the physico-chemical characteristics of the habitat, the available food, and the stomach and intestinal contents of the fishes.

Description of Study Area

Kincaid Creek, a tributary of the Big Muddy River, is located approximately six miles west of Murphysboro, Jackson County, Illinois. It is approximately 22 miles long, drains 52 square miles, and has an average gradient of 11 feet per mile. An estimated 60% of the drainage area is forested, with the remainder about evenly divided between pastures and intertilled crops. The creek flows through a narrow, steep-walled valley which seldom exceeds one quarter of a mile in width. The creek bottom is narrow, firm, and covered with rocks, gravel, and sand, except for the lower three miles which are sometimes covered with silt. The flow is normally clear and swift, but is subject to severe water-level fluctuations following heavy rainfall.

In the lower extent of Kincaid Creek the banks are steep and the stream bed as deep as 25 feet. Riffles occur only where debris dams the flow. The stream bed is free of sharp meanders and liberally obstructed with logs, drifts, and snags. Recorded depths range from two to seven feet. Normal flow at this section was 40.8 cubic feet per second in mid-April, and 0.6 cubic feet per second in early July. Water levels may rise as much as 19 feet when backwater from the Big Muddy River encroaches on this area. During periods of flooding, backwater from the Big Muddy River may stop the flow of Kincaid Creek, or even cause it to flow in a reversed direction. In either case, a deposit of silt results from the reduced velocity of the silt-laden waters. This silt is "flushed" away by subsequent high water flowing into the Big Muddy River. When not covered with this silt layer, the stream bottom is generally firm and sandy.

The middle reaches of the creek pass through a narrow, steep-walled valley. The banks are generally steep, with the stream bed as deep as 20 feet. The stream is free of sharp meanders and bordered on one side by a steep valley wall. The stream bottom is largely sand with some gravel, bedrock, and larger stones. Large pools and riffles occur and are liberally filled with rocks, tree trunks, and snags. Pools 10 to 25 feet wide and up to 400 feet in length are interspersed with riffles from 10 to 75 feet long. The normal flow in this area was recorded at 10.8 cubic feet per second in mid-April and 1.0 cubic foot per second in early July. Water levels fluctuate as much as 15 feet.

The headwaters flow through an area of moderately rugged, timbered hills. The banks are generally steep with the stream bed as deep as 20 feet. The stream meanders sharply and is characterized by vertical banks and trees toppled into the water. A definite pool-riffle development is present with the pools 8 to 15 feet wide and up to 40 feet long, interspersed with riffles up to 40 feet long. The stream bottom is sandy, mixed with gravel and stones. The normal flow was recorded at 3.5 cubic feet per second in mid-April and 0.2 cubic foot per second in early July. Water levels vary as much as 16 feet.

During the study period water temperatures varied from 38° to 85° F. and tended to fluctuate with the air temperature. The pH was fairly uniform at all sections and ranged from 7.2 to 8.0. Dissolved oxygen varied from 5.2 to 9.3 p.p.m., which is well within the range of fish requirements (Moore, 1942). Turbidity was generally moderate but fluctuated with water-level changes caused by heavy rainfall. In general, the most extreme turbidities were found in the upper and lower reaches of the creek (Table 1). The entire stream is characterized by the rapid clearing of the water following heavy rainfall.

Methods of Study

The study period extended from February 18 to July 4, 1958. Three sampling stations were established along the main channel of Kinkaid Creek and two on tributaries (Roman numerals I through V, Fig.1). These stations were selected to represent different types of habitat. A collection site consisted of a pool and associated riffle.

Surface temperature and pH were determined in the field, using a Taylor field kit and a hand thermometer. Water samples for dissolved oxygen analysis were fixed in the field and returned to the laboratory where determination in p. p. m. was made by the Winkler method (Welch, 1948). Turbidity was determined in the laboratory by use of a Hellige turbidimeter. Water samples were collected with standard collection bottles and a Kemmerer water sampler. Volume of stream flow was calculated with the aid of a Gurley Model 622-E flow meter.

Three collections were taken at each station, beginning in early March and ending in late June. Immediately after capture all fish were preserved in 10% formalin and returned to the laboratory for examination. A 12- by 4-foot, knotted, 1-mesh minnow seine with 0.25-inch mesh was employed at all stations except I. It could not be used at I due to snags, rocks and deep water.

An electrical shocking device consisting of a D. C., 180-volt, 250-watt, portable generator proved particularly useful for collecting during clear water conditions. A minnow seine was employed downstream to capture any stunned fish that floated with the current.

Fyke and hoop nets were utilized at stations I and IV where deep water, vertical banks, and snags limited the use of other types of collecting gear.

Sodium cyanide (Bridges, 1958) was used as a means of making a single collection at each station except I, in late June. When fish

FIG. 1.—Kincaid Creek drainage.

were exposed to concentrations of 1 p.p.m. sodium cyanide they became distressed and surfaced, and thus were easily netted. Although previous use of this method had been limited to farm ponds, it proved successful for stream collecting. A minnow seine was employed downstream from the collecting area to capture disabled fishes carried by the current. At Station IV the stream flow was diverted by use of an earthen dam and a canvas divider, forming a pool through which no current flowed. This pool was then poisoned and the fishes collected.

Plankton samples were taken by pouring 20 liters of water through a plankton net. Water for such samples was collected from the surface one foot of pools. Samples were examined with the use of a Sedgewick-Rafter counting cell and a compound microscope.

Several attempts were made to collect samples of bottom fauna from deep pools, but in general this proved unproductive, due to the hard, sandy bottom and the consequent lack of organisms. For this reason, all samples of bottom fauna were taken from shallow, rocky riffles using a Surber bottom sampler. Samples were preserved in 10% formalin and returned to the laboratory for examination.

Stomach or intestinal analyses were made on all species of fishes collected. One hundred was arbitrarily selected as the approximate maximum number of a species to be examined when sufficient fish were available. A detailed analysis was purposely avoided because only an

TABLE 1.—Physico-chemical Data from Kinkaid Creek, Illinois, April to July 1958.[1]

Station	Date	Air temp. °F.	Water temp. °F.	pH	Dissolved O_2 p.p.m.	Turbidity p.p.m.
I	19 April	74	66	7.5	7.2	32
IV		74	62	7.3	7.4	15
V		60	60	7.2	7.5	18
I	3 May[2]	..	..	7.7	7.1	285
II		..	..	7.3	7.4	93
V		..	..	7.4	7.6	330
I	6 May	72	60	7.3	5.8	165
II		72	62	7.3	8.3	36
III		72	58	7.9	9.3	18
V		72	62	7.4	5.1	36
I	4 July	83	76	7.3	5.7	27
II		88	85	8.0	7.2	11
III		88	85	7.4	6.7	11
IV		87	79	7.3	5.2	20
V		84	75	7.5	5.2	20

[1] Includes only samples taken from various stations during same day.
[2] 12 hours following estimated one-inch rain.

index to possible food consumption was the desired objective In fishes with poorly defined stomachs the intestinal content was examined. Although 1,258 fish were examined, only general references are made to these data in this article.

A gross gonadal examination was made of all specimens opened for stomach or intestinal analysis. An effort was made to determine from these observations the approximate spawning periods for each species.

If fewer than 25 specimens were collected of any given species the results of the food analysis and gonadal examinations were arbitarily considered inconclusive and consequently not included in this paper.

FISH POPULATIONS

A total of 38 species and one hybrid cross were taken (Table 2). In the following discussion the status of each species from Kinkaid Creek is reviewed, in addition to presenting results of food habit and gonadal examinations.

Single specimens of the longnose gar, *Lepisosteus osseus* (Linnaeus); shortnose gar, *Lepisosteus platostomus* Refinesque; and bowfin, *Amia calva* Linnaeus, were taken at station I during flood stage.

Gizzard shad, *Dorosoma cepedianum* (LeSueur).—Three taken at station I during high water.

River carpsucker, *Carpiodes carpio* (Rafinesque).—One taken at station I during flood stage.

White sucker, 0.9% of total number fish collected. This species subsisted mainly on bottom ooze, detritus, and dipterous larvae. Spawning during April and May.

Spotted sucker, *Minytrema melanops* (Rafinesque).—One adult female, taken in mid-April from station IV, contained well-developed eggs and possibly was migrating toward the headwaters to spawn.

Creek chubsucker, 0.6%. Spawning during late April and May.

TABLE 2.—Fishes Collected in Kinkaid Creek, Illinois, March to June 1958.[1]

Common Name[2]	Scientific Name[3]	Number of species by station					
		I	II	III	IV	V	Total
White sucker	*Catostomus commersoni* (Lacepede)	.....	17	6	2	1	26
Creek chubsucker	*Erimyzon oblongus* (Mitchill)	.....	5	5	6	1	17
Golden redhorse	*Moxostoma erythrurum* (Rafinesque)	.....	17	1	20	.....	38
Creek chub	*Semotilus atromaculatus* (Mitchill)	.....	51	71	111	30	263
Emerald shiner	*Notropis atherinoides* (Rafinesque)	.....	.....	.....	21	.....	21
Red shiner	*Notropis lutrensis* (Baird and Girard)	.....	28	9	76	87	200
Redfin shiner	*Notropis umbratilis* (Girard)	.....	7	9	29	32	77
Sand shiner	*Notropis deliciosus* (Girard)	.....	26	10	149	154	339
Silverjaw minnow	*Ericymba buccata* (Cope)	.....	1	.....	.....	28	29
Suckermouth minnow	*Phenacobius mirabilis* (Girard)	.....	7	23	21	9	60
Bluntnose minnow	*Pimephales notatus* (Rafinesque)	.....	58	186	424	116	784
Stoneroller	*Campostoma anomalum* (Rafinesque)	.....	20	111	139	50	320
Channel catfish	*Ictalurus punctatus* (Rafinesque)	1	.....	.....	5	.....	6
Yellow bullhead	*Ictalurus natalis* (LeSueur)	.....	17	21	11	3	52
Black bullhead	*Ictalurus melas* (Rafinesque)	2	8	8	3	.....	21
Blackstripe topminnow	*Fundulus notatus* (Rafinesque)	1	6	2	4	2	15
Pirateperch	*Aphredoderus sayanus* (Gilliams)	.....	3	3	4	.....	10
Log perch	*Percina caprodes* (Rafinesque)	.....	.....	1	22	4	27
Blacksided darter	*Percina maculata* (Girard)	.....	.....	2	6	10	18
Orangethroat darter	*Etheostoma spectabile* (Agassiz)	.....	1	20	11	9	41
Fantail darter	*Etheostoma flabellare* (Rafinesque)	.....	.....	40	129	16	185
Johnny darter	*Etheostoma nigrum* (Rafinesque)	.....	14	9	19	11	53
Green sunfish	*Lepomis cyanellus* (Rafinesque)	.....	28	33	17	7	85
Longear sunfish	*Lepomis megalotis* (Rafinesque)	.....	21	9	15	.....	45
Bluegill	*Lepomis macrochirus* (Rafinesque)	1	3	4	.....	.....	8
Orangespotted sunfish	*Lepomis humilis* (Girard)	.....	10	14	3	3	30
White crappie	*Pomoxis annularis* (Rafinesque)	22	.....	.....	.....	.....	22
Totals (including species listed in text)	.....	42	354	599	1,250	573	2,818

[1] To facilitate printing, species of lowest occurrence are listed in the text only.
[2] Phylogenetic order from Jordan, *et al.*, 1930.
[3] Eddy, 1957.

Golden redhorse, 1.3%. All specimens but one were captured with aid of sodium cyanide. Food analyses could be made for June only because of lack of representatives for other study months. Primary foods were dipterous larvae, detritus, and crustaceans. Spawning previous to late June.

Carp, *Cyprinus carpio* (Linnaeus).—Five taken at station I.

Creek chub, 9.3%.—Main foods were terrestrial insects, dipterous larvae, and plant materials. Spawning during April and May.

Emerald shiner, 0.7%.—All specimens taken same day from a deep swift riffle at station IV.

Red shiner, 7.1%.—Major foods were terrestrial insects, aquatic insects, and bottom ooze. Major spawning after June.

Redfin shiner, 2.7%.—Taken at all stations except I. Food habits of this fish differed from the other shiners in that it fed primarily on terrestrial insects during entire collecting period. Spawning began in June and extended into July.

Sand shiner, 12.0%.—Stomachs revealed bottom ooze, aquatic insects, and dipterous larvae. Spawning during late May and June.

Silverjaw minnow, 1.0%.—Collecting stations at which this species was collected indicated it to be best adapted to ecological conditions found in headwaters. Examinations of 30 individuals revealed this species fed primarily on dipterous larvae, bottom ooze, and aquatic insects. Spawning in May and early June.

Suckermouth minnow, 2.1%.—Feeds predominantly on dipterous larvae and detritus. Spawning peak in May.

Bluntnose minnow, 27.8%.—This was most abundant of all fishes and was basically a bottom feeder on dipterous larvae, bottom ooze, and plant material. Spawning after June.

Stoneroller, 11.3%.—This bottom feeder subsisted mainly on bottom ooze and dipterous larvae. Spawning peak in late April and May.

Channel catfish, 0.2%.—From deep water at stations I and IV. Although this is one of the more important sport fishes in the Big Muddy River, it appearently was not well established in Kinkaid Creek.

Yellow and black bullheads, 1.8 and 0.7%, respectively.—Stomachs of 46 yellow bullheads revealed crustaceans and aquatic insects as main foods. Spawning in May and early June.

Tadpole madtom, *Noturus gyrinus* (Mitchill).—Three collected from small tributaries at stations II and III.

Blackstripe topminnow, 0.5%.—Spawning began in late June.

Pirateperch, 0.3%.—Conclusive spawning data could not be obtained due to lack of specimens; however, some spawning in late April and early May.

Log perch, 0.9%.—Stomachs of 27 log perch revealed mainly aquatic insects, dipterous larvae, and terrestrial insects. Gonads of fish collected in late May were spent, indicating that spawning had occurred.

Blacksided darter, 0.6%.—Captured exclusively from deep pools bordered with debris. All but one specimen collected with sodium cyanide. Gonads spent when taken in late June.

Orangethroat darter, 1.4%.—Subsisted mainly on dipterous larvae, aquatic insects, and crustaceans. Spawning during late April and May. The author could not find a record of the orangethroat darter in southern Illinois. It is possible that this species has been collected and misidentified as the rainbow darter, *Etheostoma caeruleum* Storer.

Fantail darter, 6.6%.—Fed mainly on dipterous larvae, aquatic insects, and crustaceans. Spawning in late May and early June.

Johnny darter, 1.9%.—Taken at all stations except I. Foods were primarily dipterous larvae and aquatic insects. Peak of spawning probably in late May.

Spotted bass, *Micropterus punctulatus* (Rafinesque).—Single sub-adult collected at station II and another at IV. Although the habitat appeared to be favorable for this species, it was not well established in Kinkaid Creek.

Green sunfish, 3.0%.—The most abundant sport fish. Stomach analyses of 63 fish revealed primarily crustaceans, terrestrial insects, and small cyprinid fishes. Spawning peak in late June.

Longear sunfish, 1.6%.—Stomachs of 45 fish revealed primary foods to be aquatic insects, crustaceans, and terrestrial insects. Peak of spawning during June.

Bluegill. Eight specimens.

Orangethroat sunfish, 1.1%.—Stomachs of 28 fish revealed crustaceans, aquatic insects, and dipterous larvae as primary foods consumed. Spawning during May and early June.

Warmouth, *Chaenobryttus coronarius* (Bartram).—Single specimen, station IV.

White crappie, 0.8%.—Not well established in Kinkaid Creek; probably migrates upstream during periods of high water. Stomachs of 22 indicated subsistence primarily on small cyprinid fishes and crustaceans.

Black crappie, *Pomoxis nigromaculatus* (LeSueur).—Four specimens, station I.

Interrelationship Among Species

Predation among the fishes of Kinkaid Creek was low during the study. The lack of large predator fishes was a major factor. The crappies, green sunfish, longear sunfish, and creek chub were the principal predators. Starrett (1950) found that little predation exisited among similar fishes in the Des Moines River, Iowa, during the same period, but that it increased in late summer and fall as the aquatic nymphs and larvae decreased. This would possibly hold true in Kinkaid Creek, but to a more marked degree. With the coming of the dry summer months, the flow of Kinkaid Creek normally decreases, reducing the size of pools and riffles. The construction of the available habitat will naturally bring the fishes into a more confined situation and will limit the available food sources. In addition to these factors, the appearance of the recently hatched spawn would make predation more probable.

It is difficult to demonstrate harmful interspecies competition among fishes for food. Lagler (1944) stated that the fact that two or more species of fishes feed on the same organisms does not mean such competition is harmful to one of the species. If these food items are sufficiently abundant, no harm will come from such competition.

There was no apparent relationship between the comparative number of available riffle organisms and the diet of the fishes. A sizable proportion of the consumed food supply apparently came from a source other than riffles, possibly from other portions of the creek, blown in by winds, dropped from overhanging vegetation, or washed from the surrounding watershed. No attempt was made to sample these sources or determine a percentage of the overall food supply derived from them.

It was concluded from the small number of empty stomachs and from evidence of low predation among the fishes, that harmful interspecies competition for food was not great.

Plankton was studied separately due to its size and utilization by smaller fishes (Bajkov, 1932). Samples were collected from pools from April to early July. The largest numbers appeared in July, when 73, 53 and 33 plankters per liter were taken from stations I, IV, and V, respectively. Such an extremely low count may be attributed to the constantly flushing action of spring rains. Shelford and Eddy (1929) found that "new" water in the Sangamon River, Illinois, contained practically no plankton after nine days.

Bajkov (1932) stated that the greatest cause of mortality among fish fry is the lack of food, especially plankton organisms. It is probable that the most harmful interspecies competition for food is among the fish fry which feed on plankton.

Discussion

It is evident from the collections that there are few catchable size

sport fishes in Kinkaid Creek. Management procedures are impractical, due mainly to the lack of access roads, excessive flooding, and absence of desirable sport species. A large scale impoundment would be the principal requirement to improve sport fish habitat. Such an impoundment has been proposed repeatedly in the past. As recently as 1957, official mention has been made of Kinkaid Creek as a possible site for such a project (Department of Registration and Education, 1957). The construction of such an impoundment would have definite benefit toward increasing suitable sport fishing habitat at slight loss of productive farmland and wildlife habitat. Until such an impoundment is constructed, the primary fisheries resource of Kinkaid Creek is its bait fish population. Collection of bait species is facilitated by the abundance of suitable pools at stations II, III, and V. Lack of access roads prevents proper utilization of other areas where bait fishes are equally abundant.

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TOBACCO PRODUCTION IN THE PHILIPPINES

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Tobacco production in the Philippines has had a complex history. It is the oldest industrialized agricultural enterprise in the country, antedating coconut, abaca, and sugar as a major product of commerce and trade. Over the years tobacco production experienced significant changes; these trends were brought or affected by changes in political status or emphasis, by varying economic conditions and trends in world trade, or influenced by changing fashions of consumers, both domestic and foreign. Although this irregularity of production reflects physical factors, economic conditions, and social trends, it is political factors that have accounted for the larger changes over the years.

Early Developments

Spanish missionaries introduced the tobacco plant, *Nicotiana tabacum,* in the Philippines from Mexico during the sixteenth century. After it proved adaptable to Philippine soil and climate, the Spanish, in an effort to stimulate tobacco production, declared the crop a government monopoly in 1781. This royal decree placed in the hands of the Spanish Governor-General extensive powers in order that tobacco culture might be increased. However, the monopoly covered only the principal tobacco-growing regions of Luzon.

The monopoly was administered with the greatest of detail and energy. Everything from the planting of the seed to the disposal of the final product was regulated by law. Tobacco experts were brought from the Caribbean region to advise and aid in the development of the industry. These experienced tobacco men brought seeds from the finest plants then available. By experimentation the Cagayan Valley was found to be the most favorable Phillippine area for tobacco production. It was in this area that the most severe regulations were imposed. Frequent and rigid inspections were made by the local administrators. If at any time and for any reason the inspectors felt that a grower was failing to meet the high standards of quality or quantity demanded by the Spanish government, immediate public punishment was decreed against the offender. The individual grower failed to profit, except insofar as Spanish officials felt that personal favors would increase production. In manufacturing, too, the Spanish administrators were just as thorough. They brought in skilled workers and overseers, and "Manila Cigars", produced in the five large factories established by the Spanish in Manila, soon came to enjoy a reputation as the finest cigars on the market. Hence, the early development of the tobacco industry in the Philippines must be credited to the ambition of the Spanish conquerors.

In time, the very harshness with which the monopoly was administered produced a condition under which its effectiveness decreased. The

Filipino farmers organized into rebellious groups; riots and uprisings against the rigid control became prevalent. The weakened Spanish government was unable to cope adequately with this situation and in 1882, a century after its inception, the Spanish monopoly was officially abolished.

When the monopoly was finally lifted, the cultivation and marketing of tobacco were continued as a private enterprize, but with varying degrees of success. Many small factories supplanted the five discontinued government factories. These small factories, operating with little or no regulation, did not maintain the high standards that were required under the monopoly. The quality of the cigars declined and the demand decreased accordingly. It was only with difficulty that the quality of the cigar was restablished and the market partially regained

It was during this period of Philippine economic history (1882-1898) that a few commercial concerns emerged as leaders in the tobacco industry. Alhambra and Tabacalera became synonymous with Philippine tobacco and tobacco products. The "Compania General de Tabacos Filipinas," commonly referred to as "Tabacalera," can be taken as illustrative of this leadership in the tobacco industry. Tobacco was cultivated on Tabacalera *haciendas* in the Cagayan Valley and was purchased from independent growers. Much of it was used in Tabacalera-owned Philippine cigar factories. Because of established trade relations in Europe, Tabacalera became one of the leading exporters of leaf tobacco, much of it to Spain. This leadership, initially acquired during the latter part of the Spanish period, continued with some modifications during the American regimé and was reestablished after the interruption associated with Japanese occupation.

American Period

From 1900 to 1941, tobacco was a very important crop and tobacco and tobacco products for much of that time were the fourth ranking exports from the Phillipines. In 1920, the peak year, 65 million kilos were harvested from 100,000 hectares. The Manila cigar again had a world market. The impetus for this growth was primarily the duty-free American market, but the capital was not necessarily American. Spanish interests were probably the foremost, but certainly not the sole, investor in Philippine tobacco and tobacco products during the American colonial and commonwealth period.

Tobacco, although raised to some extent in almost every province, was of commercial importance in only a few localized areas. The narrow Cagayan Valley in northeastern Luzon remained the foremost area, and the Ilocos Region of northwestern Luzon was the second area of importance. To a lesser extent, tobacco was cultivated in some of the Visayan (central) Islands. Within these regions certain provinces were noted for tobacco, namely Isabela, Cagayan, La Union, Pangasinan, Ilocos Norte, Iloilo, Negros Oriental, Cebu, Nueva Ecija, and Masbate. From 1935-1939 these ten provinces produced about 85% of the entire tobacco crop, an average of 35,400 short tons annually. About one-half of the cultivated

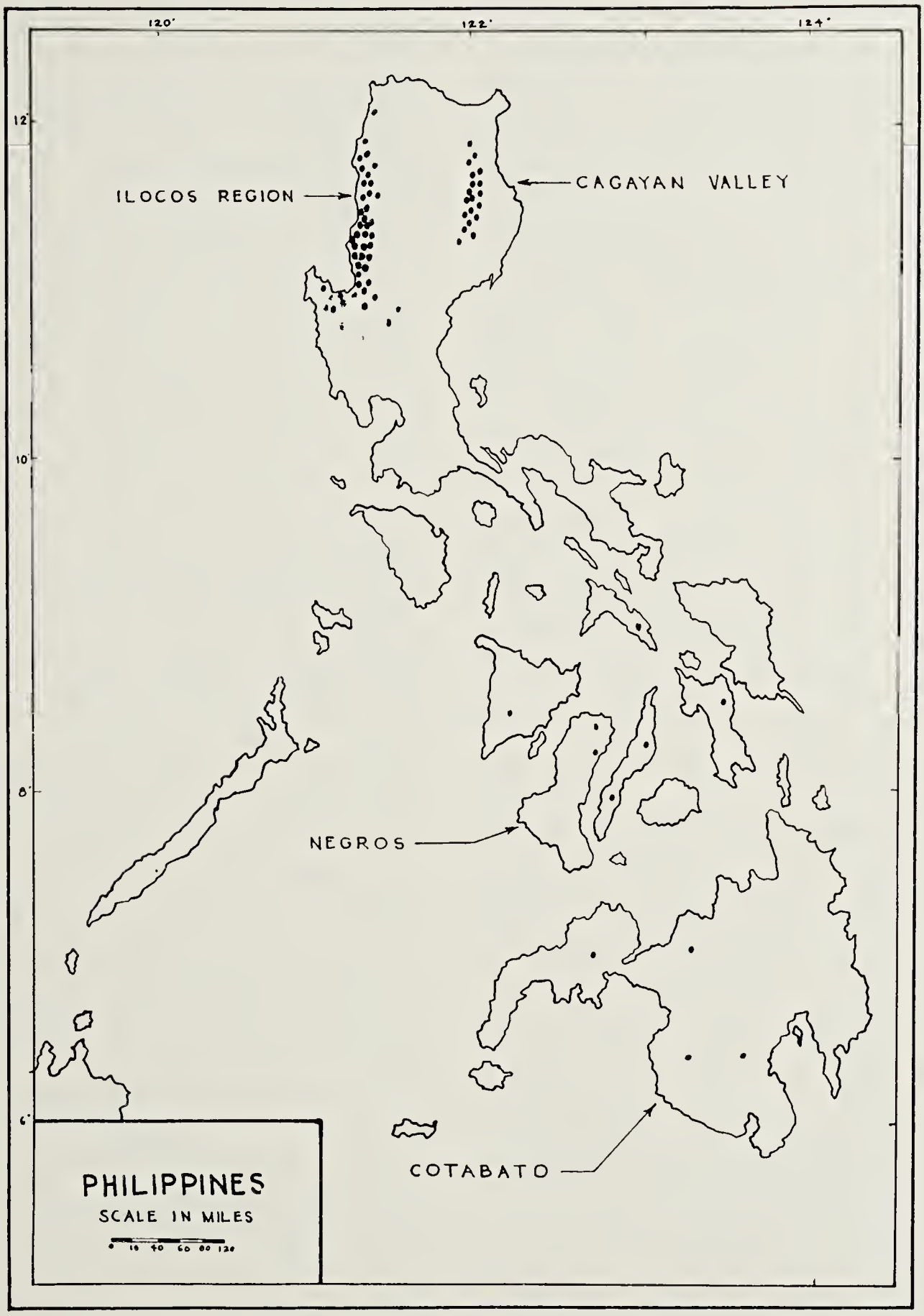

FIG. 1.—Map of Philippines showing principal areas of tobacco culture. One dot represents 1000 hectares (1956). (Data from Philippine Bureau of Agricultural Economics.)

area was in the Cagayan Valley and about 20% in the Ilocos provinces. Between 80 and 100 thousand agricultural workers were supported, at least in part, by tobacco culture. Cash return per hectare was relatively large and it provided an effective use of feminine and child labor. The intensive methods of planting, cultivating, harvesting, and curing made it particularly suitable to the small farms and large families that characterize Philippine agriculture. In 1938, 46% of the tobacco-producing land was cultivated by owners, and an additional 23% by part owners. The fact that tobacco thrives under climatic and soil conditions favorable to corn production has enabled the Filipino farmer of the Cagayan Valley to secure a second crop from the same plot each year—tobacco, a cash crop, and corn for either home use or as a secondary source of income. This helps insure against economic disaster that might result from a single-crop failure or from tobacco market fluctuations.

Cigar filler, wrapper, aromatic cigarette filler, and miscellaneous types (pipe and chewing tobaccos) were grown. All of these types were sometimes taken from the same field, or even the same plant, because the leaves from a single plant vary in quality during different stages of growth. But there was some regional specialization in terms of type of product.

Most of the good quality cigar filler was and still is grown in the Cagayan Valley, although some was produced on Mindanao. Until the last few years cigar filler was the most important type grown in the Philippines, oftentimes accounting for as much as 90% of the production. The climate and soil of Cagayan Valley are especially adapted to the production of cigar filler. The principal tobacco soil is a deep, friable, sandy loam, in good physical condition. The flood plain is oftentimes inundated by the flood waters of the Cagayan River, leaving a thin alluvial despoit and thus helping to maintain soil fertility. Furthermore, the short dry season aids harvesting and curing operations. Probably this fortunate combination of circumstances is the primary reason that the Cagayan Valley has remained the leading region for filler tobacco.

Wrapper tobacco, both sun and shade grown, was produced mainly in the provinces of Laguna, Isabela, La Union, Ilocos Sur, and Batangas, but only in limited amounts as most of the wrapper tobacco used during this period was imported from Sumatra and the United States. Each of these provinces has some areas of fertile loam soil that (for tropical soils) is rich in both organic and mineral components, a uniform rainfall throughout the growing season, and a dry season for harvesting and curing. These conditions favor the production of a leaf that is very thin and extremely mild and has a fine texture, and a uniform color, the requisites of good cigar wrapper. Other regions that seem just as favorable have never produced a leaf of the desired quality, a condition that lacks adequate explanation.

Aromatic cigarette filler was grown predominantly in the provinces of central Luzon, *i.e.*, Pampanga, Bulacan, Tarlac, Nueva Ecija, and Pangasinan. The rela-

tively infertile soil of this area was considered by some tobacco men to be an asset in the growing of aromatic cigarette filler since a desirable flavor and texture supposedly result from tobacco cultivation on soils that are not particularly fertile. There was never a large production of cigarette tobacco during the American period as both American aromatic tobacco and U. S. cigarettes were readily available. Most cheaper cigarettes were made of cigar filler.

Soil and Climatic Requirements

The different types of tobacco have slightly different soil and climatic requirements for optimum yield or quality. The normal cigar filler varieties are best adapted to areas that have adequate moisture interspersed with several drier days and friable, fertile soils. A sandy loam is recommended.

Rapid growth is desirable in all wrapper tobaccos. A fertile loam with a generous supply of organic matter is ideal. The sun-grown wrapper types are best adapted to regions with an almost even distribution of rainfall. Much of southern Mindanao has uniform, although not excessive, precipitation and is south of the typhoon belt. It is surprising that Sumatra wrapper has not become significant in Mindanao, that part of the Philippines that is climatically most like Sumatra. Experiments with Sumatra wrapper in the Cagayan Valley have not been really successful. In prewar years shade-grown wrapper was moderately successful in the interior valleys of the Ilocos region and on the volcanic soils in the vicinity of Tagaytay Ridge in Batangas. Neither area is an important wrapper area today as Virginia leaf has become "king" in the Ilocos area, and Batangas and other provinces of southern Luzon have been insignificant producers of tobacco in any form during the postwar years.

Aromatic cigarette filler is grown to greater advantage in regions that have distinct wet and dry seasons and somewhat heavier, even compact soils. Rapid growth of the plant is discouraged because a thinner leaf that oftentimes has less aroma is thereby produced. Therefore, soils of medicore fertility are recommended. In the Ilocos area and Pangasinan, Virginia-type tobacco is planted, much of it on paddy soils, immediately after the rice harvest. This region has a long dry season for harvest. Yields can be increased if irrigation is practiced. One or possibly two applications of water normally prove quite profitable, but three or more applications of irrigation water have proven uneconomical in Ilocos Sur. The quantity of tobacco is increased by repeated irrigation and the color remains good, but there is less aroma and a resulting lower classification and lower price. Some of the Turkish varieties give better quality on poor soil, but the yield is so low that there is no profit.

Tobacco is a potash-loving plant. Sufficient potash in the soil appears to improve the burning quality and also increases the oil content. Potash-deficient leaves, when cured, lack body, elasticity and aroma. Most of the soils of the Ilocos plain have inadequate potash for tobacco.

Virginia tobacco does not require a high nitrogen content in the soil, nor is high organic matter desirable.

Heavy applications of either should not immediately precede the tobacco crop. Since tobacco may follow rice in the Virginia-producing areas of the Philippines, and since rice needs nitrogen, careful fertilization of the rice crop must be practiced in order to provide an adequate amount of nitrogen for rice, but to avoid heavy applications that may eventually render the soil unsuitable for the production of flue-cured tobacco. All Philippine tobacco soils are low in organic matter, and if organic matter is added to improve soil structure, a commendable practice, it can be done when planting other crops and thereby not affect the tobacco crop in another season or year.

An adequate amount of calcium improves the taste, aroma, burn and general quality of the cured and fermented leaf. In tobacco plants, especially Virginia tobacco, a high lime content may cause objectionable flaking of the ash. Liming the soil for flue-cured tobacco is not recommended unless the pH is below five.

Culture Practices

In general, agricultural procedures followed in the production of tobacco in the Philippines are semi-primitive rather than modern. Except in a few areas, little or no fertilizer is applied and a low production per hectare may result. Seed beds are sometimes permitted to lie fallow for a year or more in areas where land is plentiful. Little machinery is used, improved machinery having been little more than introduced in the tobacco growing areas. The Philippine government has experimented extensively in an attempt to solve the various problems associated with tobacco farming, but has been unable to put many of the findings into practice because, until recently, most tobacco farmers were not especially sympathetic with or adaptable to change.

As with many other crops, the tobacco plant is nurtured in seedbeds for the first few weeks and then transplanted into the field in which it is to be grown. Most seed beds are shaded with palm leaves. In all tobacco districts of Luzon the seeding is done in September or October with transplanting in November and December. Transplanting takes place at 6 to 8 weeks, spaced 18-20 inches in rows 36 inches apart. The soil is carefully prepared for transplanting and the crop is cultivated three or more times, in almost all cases by manual methods. Harvesting is begun in January or early February and may continue through April or into May depending upon local conditions. Harvest is by priming, which consists of picking leaves singly by hand. A field is normally primed each week, in some cases more often, during the period of harvest. If all types are to be secured from the same field or plant, the harvesting of wrapper tobacco, cigar filler, chewing, and smoking tobacco is begun and completed in that order.

After priming, the leaves are laid on the ground; later, possibly the next day, they are sorted according to size, and poled. This procedure consists of folding the leaf lengthwise along the midrib and threading it on a small, pointed bamboo pole by piercing the midrib from side to side. Specific procedures are then followed in the curing of various

FIG. 2.—Tobacco seedlings under shade of coconut leaves and grass in Ilocos Sur.

types. The poled wrapper types, which are not folded before poling as are the other types, are placed in the curing barn on racks without exposure to the rays of the sun. About 26 to 32 days are required for curing. Filler and miscellaneous types are exposed to the direct rays of the sun for three days and then placed in the curing barn, or whatever shelter is used, and the process is completed in 18 to 22 days.

Since 1950, most aromatic cigarette tobaccos have been cured in specially built flue-curing barns, some privately owned and some, particularly the redrying barns, owned and operated by the national government or by a cigarette manufacturing concern. The facilities are generally poor and oftentimes unsanitary so there is some deterioration and spoilage. The flue-curing barns are normally well-constructed and operated much as are those of the United States and Canada; some are operated efficiently. Although curing conditions are specified by law, enforcement is oftentimes lax. However, the general low quality of Philippine cigarette tobacco is more often the result of inefficient field operations or improper handling, rather than improper curing.

Diseases and Pests

The most serious disease of Philippine tobacco is greenleaf spot which affects shade-grown wrapper. It is most prevalent when harvest coincides with humid weather. Mosaic and other wilt diseases, although generally less serious, may become locally significant among areas of open culture production. The only practical remedy for wilt is crop rotation and development of more resistant varieties.

Two pests are prevalent, tobacco worm, *Protoparce quinquemaculata*, and cigarette beetle, *Lasioderma sennicorne*. The cutworm feeds voraciously on the tender leaves and is especially destructive during the drier season, from November until March. The long-horned green grasshopper is also destructive, but less so than the cutworm. Both can be

FIG. 3.—Harvesting tobacco in La Union. Women do much of the harvesting; they are less likely to assist with planting operations.

controlled by hand picking or by dusting with arsenic power or other insecticides. Insecticides are used if finances permit.

The cigarette beetle affects leaf tobacco and manufactured products. The only effective measures of control are sterilization and strict observance of sanitary measures in barns and storage areas.

FIG. 5.—Flue-curing barns surrounded by coconuts, mango trees and bananas. Although a cluster of a dozen, or even three or four dozen, individual barns is not unsual, this battery arrangement of barns is not common.

POST-WAR TRENDS

During the period of Japanese occupation commercial tobacco production in the Philippines was negligible. When the industry was rehabilitated after the war it faced a completely different set of circumstances. The foreign market for the famous Manila cigar had been lost and could not be regained. Apparently cigar smokers had acquired the taste for other cigars during the period that Manila cigars were not available, although there were other conditions, primarily economic factors, that were significant. Then too, the postwar Philippine public demanded greater quantities of American-type aromatic cigarettes, apparently a taste acquired and cultivated during the months of liberation and the years that large numbers of allied forces were stationed in the Islands. In 1950 Philippine tobacco production was only about 70% of the prewar production and imports (Virginia-type leaf tobacco) totaled about 50% of the Philippine production.

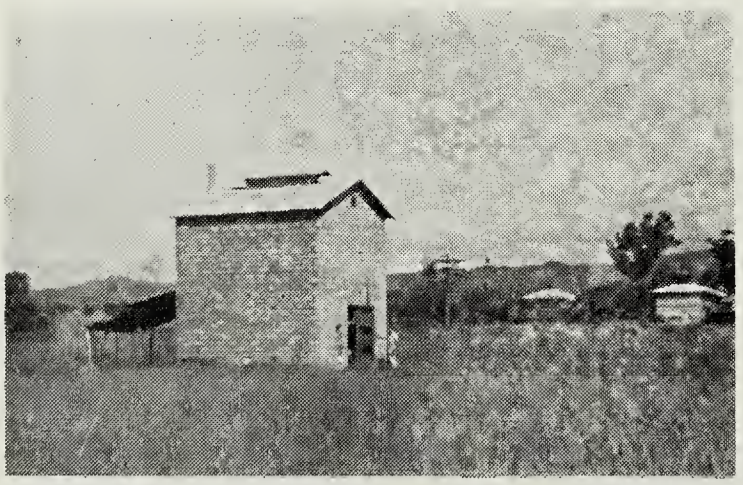

FIG. 4.—A concrete-block flue-curing barn amid rice paddies in Ilocos Sur. Barns may be constructed of galvanized iron, concrete blocks, wood, or mud over a lattice-work of split bamboo. Most roofs are galvanized iron.

Virginia leaf was introduced into the Philippines and the first flue-curing barns were built in 1950, in an effort to supply the expanding domestic aromatic cigarette industry as import controls restricted the imports of American tobacco and cigarettes. However, it was not until the passage of the government price-support program in 1954 that tobacco production regained its prewar position among the agricultural crops, with the biggest expansion from 1955 to 1957.

Price supports have been unrealistically high, and even inferior grades of Virginia leaf were included in the support program. This program was responsible for a very rapid expansion of the tobacco industry with the emphasis on quantity rather than quality tobacco. In August, 1957, supports were re-

moved from the very low grades but continued to be abnormally high on those grades that remained within the support program.

Most of the expanded production of Virginia leaf has been in the Ilocos Region, particularly in La Union and Ilocos Sur, but also in eastern Pangasinan and, to a lesser extent, in Nueva Ecija and Negros Occidental. It is interesting to note that the production of the Cagayan Valley has not changed materially, either in amount or kind of tobacco. Isabela, historically the principal tobacco province, produced less than 50 hectares of Virginia tobacco in 1956. Experiments have indicated that Virginia leaf tobacco does not have aromatic quality when grown in the Cagayan Valley.

TABLE 1.—Production and Imports of Virginia-type Tobacco.

	Production, in kilos	Imports in, kilos
1945-49 av. . . .	insignificant	112,466
1950.	100,000	13,060,151
1951.	400,000	4,477,391
1952.	1,407,000	14,761,128
1953.	1,519,000	11,543,314
1954.	2,051,170	6,598,763
1955.	6,829,540	11,158,495
1956.	21,906,490	4,256,459
1957.	31,824,318	not available
1958 estimate.	29,955,000	4,500,000

TOBACCO MANUFACTURE

Cigars, cigarettes, pipe tobacco, and chewing tobacco are manufactured in the Philippines. There are many small factories in the provinces, but the greatest concentration of tobacco processing is in the Manila area. 1939 there were 112 tobacco factories in the Philippines; 41 were in Manila. However, the Manila factories were, in general, the larger ones and, consequently, accounted for a much larger percentage of the total production than their number indicated. In fact, the tobacco industry ranked first as an employer of manufacturing labor in Manila in 1939.

Until recently cigar manufacturing has been the most important aspect of tobacco manufacturing. It is a hand operation, a skill that has developed through centuries of experience. Although the wage of the Filipino cigar maker has never been enviable, minimum wage laws have materially improved his position. This increased cost of labor has been a principal cause of the inability to regain foreign markets in the post-war years. Good Manila cigars are no longer cheap cigars. The filler tobacco used in cigars must go through a three-year curing process and a three- to four-month steam sterilizing process before it is ready for use. In prewar years it was necessary for the manufacturers to import essentially all of the wrappers used, and especially that used for the cigars made for export to the United States. Even with the imposition of import controls 90% of the wrapper is imported, most of it from the United States.

The manufacture of cigarettes has ranked second to that of cigar manufacturing, but it is doubtful if this remains true since 1958. In recent years the cigarette factories have begun to mechanize, some factories using machines for the entire process. Since greater mechanization of the industry would result in more un-

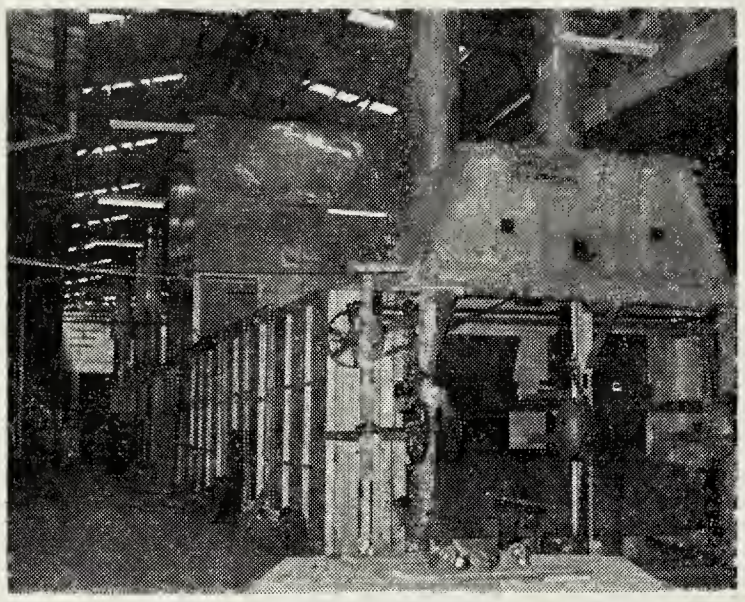

FIG. 6.—Modern tobacco-drying equipment. (Courtesy Philippine Tobacco Flue-curing and Redrying Corp.)

employment, government policy discouraged mechanization by a higher tax on machine-made cigarettes than on those manufactured by manual methods. Cigarettes are produced largely for domestic consumption in spite of the attempts of manufacturers to appeal to the cigarette taste of the foreign market by importing flue-cured tobacco from the United States to blend with Philippine aromatic tobacco. Imports of Virginia-type tobacco are supposed to be on the banned list, but a barter contract was permitted in January, 1958, which would permit the import of 10 million pounds of high grade U. S. Virginia leaf in exchange for 14 million pounds of low grade surplus Philippine Virginia leaf. The manufacture of cigarettes is definitely concentrated in the Manila metropolitian area. Seventeen factories produce Virginia-type cigarettes; 6 of them account for 95% of the total production (1957 figures).

Chewing and pipe tobaccos are manufactured entirely for local use. Most of them are made from the thickest and darkest leaves and do not have the benefit of flavoring or blending. Much of the chewing tobacco is made in the form of twists or sticks. Most pipe tobacco is shredded in the same manner as cigarette tobacco. Only one brand of pipe tobacco is cut and blended in a manner comparable to foreign brands, and it is not readily available, even in Manila.

SUMMARY OBSERVATIONS AND PROSPECTS

The tobacco industry, although overshadowed by sugar, coconuts and abaca, is an important industry in the Philippines. In recent years about 20% of the total income of the Bureau of Internal Revenue has been

TABLE 2.—Tobacco Production (hectares) Philippines and Selected Provinces, 1956.

	Native	Virginia leaf	Total
Philippines...	39,770	35,330	75,100
Isabela....	14,700	30	14,730
Cagayan...	3,480	40	3,520
La Union..	700	15,150	15,850
Ilocos Sur..	2,500	8,450	10,950
Ilocos Norte	560	2,240	2,800
Abra.....	700	270	970
Pangasinan.	6,500	5,460	11,960
Nueva Ecija	900	1,300	2,200
Cotabato...	1,330	80	1,410
Cebu.....	1,930	.....	1,930
Leyte.....	810	.....	810
Negros Occidental..	700	730	1,430
Iloilo.....	680	.....	680
Masbate...	420	10	430
Negros Oriental....	430	80	510
Pampanga..	.....	430	430
Zambales...	30	430	460

supplied by tobacco. These collections may be even higher in future years as a rate increase on cigarettes was passed during the 1956 session of Congress.

Although Philippine tobacco production in 1956 (40,000 metric tons) was more than during the 1934-1938 period (35,000 tons) its relative position among the major world producers has declined. During this interval the production of the United States, Southern Rhodesia, Thailand, and Canada has increased greatly and that of Brazil, Turkey, Japan, Italy, France, Mexico and Cuba has increased much more than has Philippne production.

The 1956 exports (almost 7,710 metric tons) are about 80% that of the 1938 figure (9,840 metric tons), but the relative position of tobacco in the value of total exports is much less than in prewar years. The value of some of the metallic products, particularly chromite ore and copper concentrates, is considerably greater than in 1938 and the production of some other export commodities (copra and canned pineapple, for example) has expanded considerably. Spain is the principal foreign market for Philippine leaf tobbacco and the United States, actually Hawaii, is the principal importer of Phillippine cigars.

Philippine native tobacco bears the same reputation in Asia that Cuban tobacco does in the Western World, and in general the export has been comparable. In each case the quantity production has been cigar filler and has been grown for both domestic and foreign markets. Philippine production was well above that of Cuba in the pre-war years, but has been below the expanded Cuban post-war production.

Although the production of Virginia leaf tobacco is almost equal to that of all other tobaccos and the rate of increase in production has been phenomenal, it is not yet truly established. It has boomed because of import controls and high support prices. The quality of the product is not yet satisfactory and the cost of production is high. Nonetheless, the Virginia tobacco industry is potentially strong. Its problems appear to be the result of the inexperience of the grower and the lack of incentive to improve and acquire experience. This results, at least in part, from the government policy of subsidizing incompetence with extravagant support prices. This situation could be remedied by the adoption of one or more of a series of measures: reduction of support prices by at least 25% and withdrawal of support prices from any tobacco that does not qualify for the top two or three of the present six grades; establishment of a rigid and official grading system, with national and international recognition, and comparable to the world-famous Philippine abaca sorting and grading system or patterned after the practices of tobacco grading houses that have been instrumental in the recent expansion of the Rhodesian tobacco industry; prohibition of the growth of other tobacco within 25 miles (or some other workable distance) of Virginia-type tobacco areas, a method that has proven successful in Thailand where tobacco production is under rigid government control; more scientific seed selection and plant distribution, pos-

sibly licensing seed producers, and careful fertilizing. Philippine tobacco yields are too low to be really competitive on the world market.

The Ilocos Region has been most affected by the recent developments. Long characterized by poverty, there is now much evidence of prosperity. Many new and large homes have been built and are being built along the highway and in the towns. There are more work animals than at any time since the war and they are in good physical condition. New lands, mostly uplands, have been placed under cultivation. This condition, plus the increased clearing of secondary forests to obtain fuel for the flue-curing operations, has created additional problems of soil erosion and erosion control.

Theoretically tobacco is the second crop on rice lands in the Ilocos provinces, but the "second crop" has become the first crop in terms of income produced per hectare. It is the second crop only in terms of the date of planting. Despite this increased production, it appears that tobacco has not displaced any single crop in the entire Ilocos area. In Ilocos Norte it has replaced garlic, cabbage and other vegetables to some extent. In Ilocos Sur and La Union there has been a minor decrease in corn or rice in a few municipalities, but this condition is not representative throughout either province. (The Agricultural Economics Division crop forecast in late 1957 indicated that the 1958 corn crop in the Ilocos Region was expected to be almost 15% below the 1957 figure and attributed this decrease primarily to the shift to the production of Virginia leaf tobacco. However the entire Ilocos area produces only one percent of the Philippine corn, so this is in no way a major agricultural change.) There is somewhat less sugar cane grown than formerly, but the Ilocos is a marginal sugar area and the decrease in sugar hectarage cannot be attributed solely to the increased interest in tobacco.

As a result of the increased use of irrigation for a second crop of rice, corn, or vegetables, along with the additional land under cultivation, overall food production has not been greatly affected by the increased production of tobacco. Nonetheless, the Ilocos provinces have a greater food deficit than in 1950, but this condition is a reflection of the increased purchasing power of the population rather than decreased production of food products within those provinces.

Acknowledgment

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DEVELOPMENT OF *XENOPUS* OVARIES AND TESTES GROWN TOGETHER IN ORGAN CULTURES

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INTRODUCTION

Organ culture methods have been used to gain additional information concerning the process of sex differentiation in amphibians. The primary purpose of this study was to determine the time in larval development at which the sex inductor substances (Witschi, 1914, 1931) have their greatest influence. Comparisons are made between results presented here and those described by Chang (1953) for parabiotic experiments with *Xenopus laevis*.

This study was supported by grants from the Graduate School, Southern Illinois University, and the U. S. Public Health Service.

MATERIALS AND METHODS

Ovaries and testes of *Xenopus laevis* were placed in direct contact with each other in organ cultures. Seventy-three cultures were prepared in which four pairs of explants were placed in each culture dish. Since the larvae from which gonads were taken were in different stages of development they were placed in groups designated A, B, C, D (Table 1). Developmental stages were determined from Nieuwkoop and Faber (1956).

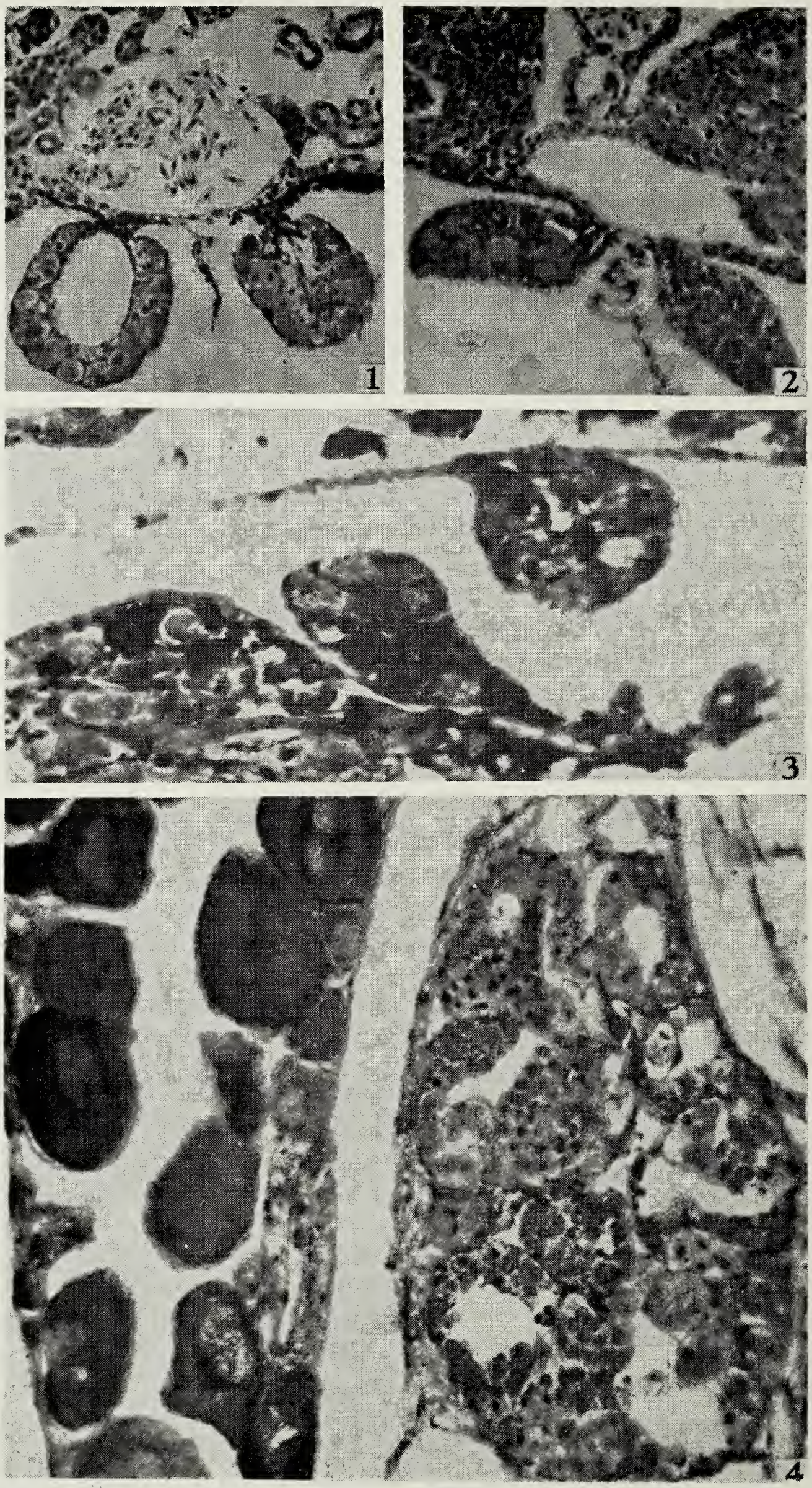
Group A consisted of gonads from tadpoles at developmental stage 53. Group B was made up of gonads from larvae of stage 53-54 combined with those from larvae of stage 56-57. Groups A and B were cultured with gonads attached to kidneys. Group C consisted of cultures in which one-third of an ovary was placed in direct contact with one entire testis, both of which had been removed from animals at the time of metamorphosis. Group D was composed of cultures of equal sized pieces of ovary and testis from two-months-old frogs.

Techniques and procedures used in preparing cultures of amphibian gonads have been described (Foote and Foote, 1958).

All cultures were continued for 30 days, with the exception of those of Group D which were maintained for 10 days. Control gonads from intact animals were fixed at the beginning and end of the culture period. *In vitro* controls were obtained by culturing individual gonads and gonad pairs of the same sex, concurrently with those in heterosexual combinations. Gonads were preserved in Zenkers's fixative, sectioned at seven microns, and strained with Harris' hematoxylin and chromotrope-2R.

RESULTS

Controls—Gonads removed from intact larvae were larger and better differentiated than corresponding gonads maintained in culture. Uncultured gonads were more compact and germ cells were distinct (Figs. 1, 2). Control gonads which had been maintained in culture were not



Gonads of *Xenopus laevis*. Fig. 1.—Ovaries of control larva, *in vivo* just prior to metamorphosis (stage 59-60). x220. Fig. 2.—Testes of control larva, *in vivo* just prior to metamorphosis (stage 59-60). x220. Fig. 3.—One ovary from stage 53 larva, the other from stage 57, together *in vitro* for 30 days. x460. Fig. 4.—Ovary and testis, *in vitro* for 10 days, from two-months-old frogs. x130.

of uniform shape and were less well differentiated than gonads from *in vivo* controls, but germ cells could be easily recognized (Fig. 3). In Groups A and B the male-male and female-female combinations served as controls

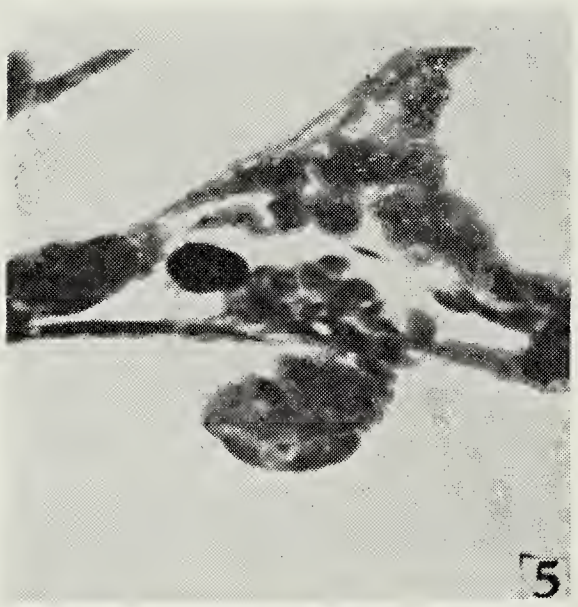
Group A—Gonads from larvae of developmental stage 53, after 30 days *in vitro,* were smaller than those from intact control animals. Although the organs were varied in shape, germ cells were distinct. There were four male-male combinations, and all these gonads were of the same size and degree of differentiation at the end of the culture period. In the three female-female combinations the ovaries were of equal size and showed the same degree of differentiation. In the nine heterosexual pairs, the testis predominated (Fig. 6). In five of these the ovaries appeared to be small and immature (Fig. 5) and in the other four pairs the testes had apparent normal structure, but gonads with which they were paired were intersexual. Since the sex of all gonads was readily apparent, some differentiation had occurred while the organs were in culture. Stage 53 is the time of early sex differentiation.

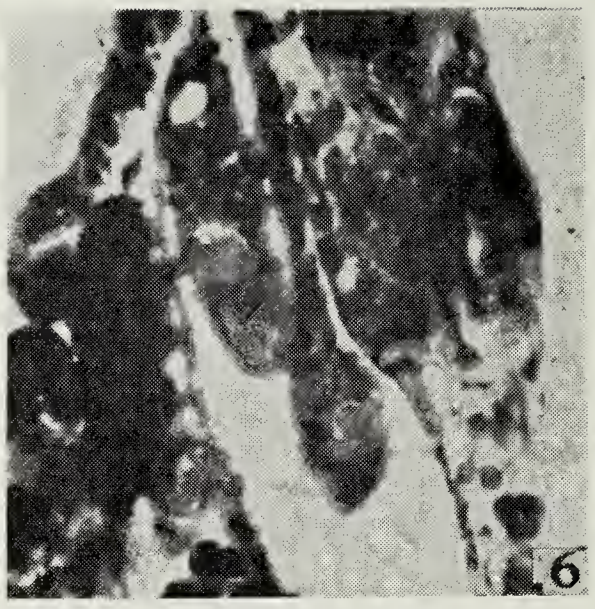
Group B—After 30 days *in vitro* these gonads were smaller than those from intact control animals, and the non-germinal cells were somewhat more dispersed. The form of the cultured gonads varied from long, slender ribbons to small cylinders, and others were of more irregular shape.

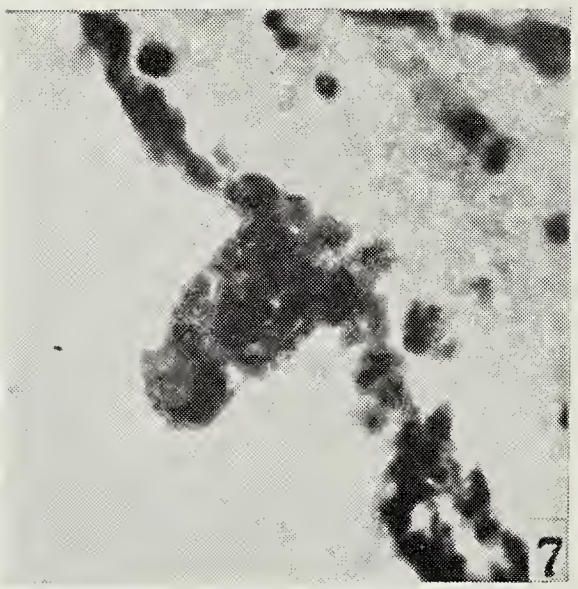
Ovaries appeared to differentiate earlier than testes. Of the 17 combinations maintained in culture there were five female-female pairs. In four of these the gonads were of the same size and showed the same degree of differentiation (Fig. 3) but in one case the younger gonads (stage 53) were less well developed. There were two male-male combinations in which the stage 53 gonads were smaller and less well differentiated than those of stage 57. In one case a testis was paired with an undifferentiated gonad. Of the nine heterosexual pairs the gonads in four were of the same degree of development. Four pairs showed inhibition of the ovarian cortex (Figs. 7, 8). One heterosexual pair was composed of a large ovary and a relatively smaller testis. No intersexes were observed. In this group where ages of larvae differed it was assumed that the larger explant came from a larva of stage 57.

Group C—Non-germinal cells intermingled at points of contact of the organs. All cells of the testes were in good condition, and in some instances the seminiferous tubules had well-developed cavities (Fig. 1). There were few ovogonia in ovarian explants and most auxocytes had degenerated (Fig.9).

Group D—At the area of contact between ovaries and testes there was an intermingling of non-germinal cells, but the germ cells remained separated. Ovaries contained auxocytes, and in some cases many ovogonia, while testes had germ cells in all stages of maturation, including mature spermatozoa. There was no change in the sex of the gonads, but those seminiferous tubules nearer the ovarian explant were more distended than in other areas (Fig. 4).







Gonads of *Xenopus laevis*. Fig. 5.—Ovaries of larva of stage 53, *in vitro* for 30 days with testes (Fig. 6). x420. Fig. 6.—Testes of larva of stage 53, *in vitro* for 30 days with ovaries (Fig. 5). x420. Fig. 7.—Ovary of larva of stage 57, *in vitro* for 30 days with testis of stage 53 (Fig. 8). x 390. Fig. 8—Testis of larva of stage 53, *in vitro* for 30 days with ovary of stage 57 (Fig. 7). x390. Fig. 9.—Ovary, *in vitro* for 30 days, from larva at metamorphosis. Paired with testis (Fig. 10). x250. Fig. 10.—Testis, *in vitro* for 30 days, from larva at metamorphosis. Paired with ovary (Fig. 9). x250.

TABLE 1.—Developmental Stages, Cultivation Time and Final Sex Distribution.

Group	Stage	Days in vitro	Explants	Final sex distribution in vitro ♂-♂	♂-♂♀	♂-♀	♀-♀	♂ undiff.	Controls in vitro ♂	♀	in vivo ♂	♀
A	53	30	16 pairs	4	4	5	3	0	4	3	2	3
B	53-57	30	17 pairs	2	0	9	5	1	4	3	11	12
C	At meta-morphosis	30	14 testes	0	0	14	0	0	6	6	10	4
			14 ovaries	0	0							
D	Frogs	10	26 testes									
			26 ovaries	0	0	26	0	0	5	6	7	2

DISCUSSION

Studies on frogs have shown that the inductors of sex differentiation are located in the cortex and the medulla of gonads (Witschi, 1914, 1931). Cortical substances induce ovarial differentiation, and medullary substances induce testicular differentiation.

If the cortex of a gonad of a genetic female is destroyed, the suppressed medulla is given a chance to grow and initiate testicular differentiation. In the transformation of a genetic male into a female the reverse is true, but in males the cortex usually disappears early in development. Consequently, male to female sex inversions are restricted to early embryonic or larval stages (Witschi, 1931). It has been demonstrated by parabiosis experiments that the inductor substances travel by diffusion through the tissues in frogs. They suppress differentiation of the gonads of the opposite sex which results in partial or complete sterility.

The time during embryonic development at which the progress of gonad differentiation can be influenced to the greatest degree has been investigated by Chang (1953). He reported that testes inhibit the development of ovaries of larvae of *Xenopus laevis* in heterosexual parabiotic combinations, and that the male inductor substance has its maximum potency some time after metamorphosis, but prior to sexual maturity. The female is maximally susceptible to the male inductor during the early larval period.

Results from the present experiment shows that with gonads from larvae of stage 53 (Group A) the testis predominates by depressing cortical development, and causes some ovaries to become intersexual. Heterosexual pairs where one set of gonads is from a larva of stage 53 and the other from a larva of stage 57 (Group B) give less clear results. Four, and possibly five, heterosexual pairs demonstrate that the testis is predominant since the ovarian cortex is much reduced. However, in four instances the testes and ovaries show comparable degrees of differentiation, equivalent to that of controls, and in one pair the testis is much smaller than the ovary. The male inductor substance from the older larvae depresses cortical development of the younger ovaries. However, when ovaries are from older

larvae, both ovaries and testes are in comparable stages, with a single exception, at the end of the culture period. In heterosexual pairs from metamorphosing animals (Group C) ovaries develop less well than testes. In general these results substantiate the findings of Chang (1953).

The predominance of the male gonad, as indicated by results from this study, suggests that the substance depressing ovarian development is not a sex hormone, since it has been shown that certain estrogens and androgens bring about reversal of males to females (Witschi and Allison, 1950; Chang and Witschi, 1955, 1956; Gallien, 1956).

Several factors must be considered in comparing results from the present *in vitro* studies and those from *in vivo* experiments. Gonads maintained in culture do not develop and differentiate as rapidly as do those of control animals *in vivo*. Consequently, at the end of the culture period, organs may not be in the same stage as those from intact animals of comparable ages. Another factor is the transmission of the inductor substances from one pair of gonads to the other in parabiosis and in culture, by diffusion through the tissues or the medium surrounding the gonads. The distance between gonads may be of little significance since no marked differences are observed between heterosexual pairs that are in direct contact and those some distance apart. Thirdly, gonads in culture apparently became modified biochemically, as has been indicated when gonad explants are transplanted into intact larvae after having been in culture for from 30 to 42 days (Foote, Mathews, and Foote, 1959).

Summary

1. Ovaries and testes of tadpoles and frogs of *Xenopus laevis* of varying ages were grown together in organ cultures on a medium of chick embryo extract and chicken plasma.

2. Heterosexual combinations of gonads made at time of early sex differentiation demonstrate that the testis is the predominant organ, depressing ovarial activity and influencing the formation of intersexes

3. Gonads grown in combination from larvae of different ages show that testes depress ovarian development in 50% of the heterosexual combinations.

4. In ovary-testis pairs from larvae during metamorphosis the testes are better differentiated.

5. No marked changes are observed in the ovaries and testes grown together if they are from frogs two months old.

6. Sex inductor substances are present in gonads during early sex differentiation and the inductor from the medullary area of the gonad is predominant until soon after metamorphosis.

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AN ANALYSIS OF THE SHELLS OF FRESH-WATER MUSSELS GATHERED BY INDIANS IN SOUTHWESTERN ILLINOIS

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Introduction

Fresh-water mussels appear to have played an important role in the lives of the Indians who formerly occupied Illinois. The presence of shells in middens, mounds, and other structures associated with many ancient Indian villages is evidence that the clam was a highly desirable item as food. The valves were also utilized as hoes, utensils for eating, and sometimes as ornaments or, more commonly, as parts of them. Their abundance and the ease with which they could be gathered from the rivers added to their value.

Many of the shells which were discarded, regardless of the date, have remained intact, and thus identifiable to the present day. All have been covered with soil, usually through the flooding of a nearby stream. Shells least exposed to prolonged wet periods have disintegrated less than those located directly on a flood plain which is periodically inundated; also, the lower ground is more liable to be acidic, a condition which quickly destroys shells.

It has long been established that fresh-water mussels are often exacting in their habitat-demands, and, if not, they nevertheless exhibit strong habitat-preferences. One would never find *Elliptio dilatatus* in standing water with a silt substratum, nor *Anodonta grandis* in rapidly flowing water on a gravel-sand substratum. Certain mussels, for example, *Lampsilis siliquoidea,* are more tolerant in their requirements and can be found in unionid communities representing many ecological backgrounds.

Several years ago, a large number of shells which were once collected and the soft parts apparently eaten by Indians were identified by the author. They had been found in middens from a single Indian village (1953). It was evident that with the exception of a few species, the mussels represented a typical unionid community as found in a small river; further, the habitat-demands of most species grossly depicted the rate of flow, presence of gravel, mud, and several other stream characteristics which once must have been present. After describing the stream as it should have been formerly, a trip to the site revealed that the shore line and areas of the substratum, as described, were still in evidence. At present, the stream flows at least 15 feet below its former bed.

A collection from another village site farther down the stream was later identified and studied (1958). As was expected, the composition of the inventory revealed that both the species and the numbers of each were somewhat different from those recorded from the first location. Logically, the concept of the stream as it formerly existed was changed accordingly.

Before a description of a former river, as shown by mussels collected at the time involved, can be attempted, certain perquisites must be recognized. The Indians must not have shown discrimination during their collecting of clams for food. They also must have occupied a site long enough to have collected thoroughly, not only in shallow water but in deeper areas during periods of drouth. One may expect to find several forms which do not fit the general picture because, on occasion, mussels could have been carried comparatively long distances by canoe, or, perhaps, over land from a nearby stream of different dimensions.

Acknowledgment

The author is indebted to Dr. John C. McGregor, Professor of Anthropology, University of Illinois, for the large collection of shells which are discussed in this paper. Information relating to the Archaic culture, as well as several others, has been generously given by both Dr. McGregor and Dr. Elaine Bluhm, also of the Department of Anthropology.

Description of Site

The shells were removed from a large refuse pile at the site of a former Indian village by McGregor. He has named the area the Chrisman Site. It is situated in Pike County, west of Meredosia, Illinois (T16NR-2WS2). It is about one and one-half miles from the west shore of the Illinois River and is two and one-half miles from the western edge of the flood plain. The terrain becomes very soft when wet and is completely flat. Running to the northeast, one-half mile west of the site, is a meandering, ancient bed of McGee's Creek. It now contains only standing water. The nearest point on this creek is at present roughly three miles from the site. Without doubt, the site has been flooded many times by the Illinois River.

A complete history of the site was presented by McGregor (1954). The shells were gathered 6,490 ±300 years ago by Indians belonging to the Archaic culture. The dates of all sites mentioned in this paper result from carbon[14] determination obtained by McGregor.

Later, reference will be made to a collection from one other site on McGee's Creek (1958). The Irvin site (Late Hopewell culture, about 776 A. D.) is located one-half mile above the point where the stream enters the flood plain. Further anthropological features of this site have been described by McGregor (1958).

Results

The shells were in various stages of decomposition. Many were softened to the extent that a valve would crumble under slight pressure. Valves of certain thick-shelled species fell apart so that several definite year's growths became separated. Other species slaked mostly at the periphery of the valve. Surprisingly, the umbos of several thin-shelled valves, all of one species (*Strophitus rugosus*), were identifiable. The posterior tips of valves of several species were gone, and their length could not be measured. It could not be decided whether this was done by Indians or by processes of erosion. Several hundred valves

had disintegrated to the extent that they could not be identified.

No terrestrial snails were found. The area has been flooded often, and, for this reason, has not been suitable for their habitation. Their absence also signifies that the Indians of this site did not eat them. Six shells of a large aquatic operculate snail, *Viviparus contectoides,* were identified. They may have been eaten, but, as the shells were still intact, they were more liable to have been carried accidentally with clams when the latter were gathered by hand and brought to the fire to be cooked. As pottery had not yet been invented, the means by which mussels were cooked remains a question.

The collection includes 32 species of 20 genera; it represents the most shells that have been recovered and identified from a site of a former Indian village in Illinois (Table 1).

TABLE 1.—Species of Unionids Found at Chrisman Site, Illinois.

	Number of identifiable valves	Number for height only	Number of complete valves	Mean for height only (in cm.)	Mean for height (complete valves, in cm.)	Mean for length (in cm.)	Percent of total population
Elliptio dilatatus (Rafinesque), 1820	808	427	299	3.0	3.1	6.2	29.3
Fusconaia undata (Barnes), 1823	369	213	93	3.2	3.2	3.5	13.4
Quadrula pustulosa (Lea), 1831	329	122	43	3.7	3.6	3.8	11.9
Fusconaia ebenus (Lea), 1831	260	92	37	3.8	3.8	4.1	9.4
Actinonaias carinata (Barnes), 1823	257	122	18	4.6	4.5	6.7	9.3
Amblema peruviana (Lamark), 1819	189	68	16	4.0	3.8	5.0	6.9
Quadrula metanevra (Rafinesque), 1820	119	60	15	4.0	4.0	4.7	4.3
Quadrula nodulata (Rafinesque), 1820	77	30	7	3.5	3.3	3.6	2.8
Amblema plicata (Say), 1817	65	12	0	3.8	.....	.....	2.4
Plethobasus cyphyus (Rafinesque), 1820	31	23	1	4.4	3.5	4.5	1.1
Ligumia recta (Lamark), 1819	30	9	2	3.9	3.8	8.9	1.1
Obliquaria reflexa (Rafinesque), 1820	30	21	0	3.0	.....	.....	1.1
Quadrula quadrula (Rafinesque), 1820	29	15	7	3.3	3.2	3.6	1.1
Plagiola lineolata (Rafinesque), 1820	27	17	10	3.9	3.9	5.2	1.0

TABLE 1 (cont.)

	Number of identifiable valves	Number for height only	Number of complete valves	Mean for height only (in cm.)	Mean for height (complete valves, in cm.)	Mean for length (in cm.)	Percent of total population
Lampsilis siliquoidea (Barnes), 1823	23	8	2	3.9	4.0	7.3	.83
Lampsilis ventricosa (Barnes), 1823	23	1	0	4.0	.....	.....	.83
Cyclonaias tuberculata (Rafinesque), 1820	15	10	0	5.1	.....	.....	.54
Amblema costata (Rafinesque), 1820	14	4	0	4.4	.....	.....	.51
Tritogonia verrucosa (Rafinesque), 1820	14	5	5	4.0	4.0	6.1	.51
Truncilla truncata (Rafinesque), 1820	13	10	0	3.2	.....	.....	.47
Fusconaia flava (Rafinesque), 1820	6	4	2	2.8	2.7	3.3	.22
Lampsilis anodontoides (Lea), 1831	6	1	1	3.2	3.2	6.7	.22
Lasmigona costata (Rafinesque), 1820	4	2	1	4.6	4.5	8.8	.14
Obovaria olivaria (Rafinesque), 1820	4	2	0	3.8	.....	.....	.14
Obovaria subrotunda (Rafinesque), 1820	4	0	0	.....	.....	.....	.14
Megalonaias gigantea (Barnes), 1823	3	3	1	5.3	5.0	6.9	.11
Pleurobema coccineum (Conrad), 1836	3	2	1	3.2	2.3	3.0	.11
Strophitus rugosus (Swainson), 1822	3	0	0	.....	.....	.....	.11
Actinonaias ellipsiformes (Conrad), 1836	1	1	1	2.3	2.3	3.8	.04
Arcidens confragosus (Say), 1830	1	1	1	4.0	4.0	5.5	.04
Elliptio crassidens (Lamark), 1819	1	0	0	.....	.....	.....	.04
Micromya iris (Lea), 1830	1	1	1	2.4	2.4	4.9	.04
Totals	2759	1286	564				100.00

Discussion

Of the list (Table 1), the following mussels are found primarily in large rivers, although they may enter the mouths of smaller tributaries for varying distances: *F. undata, F. ebenus, A. peruviana,* and *A. plicata.* These mussels require a firm substratum, but silt may either cover the surface or be mixed with it. These species constitute 32% of the population and were probably taken mostly from the Illinois River.

Q. nodulata, P. cyphyus, O. reflexa, P. lineolata, M. gigantea, and *E. crassidens* are found in large rivers usually, but it has been observed that they will ascend rivers considerably farther than those previously mentioned. Because of this, it seems probable that most of this group which constitutes 6% of the collection, came from the Illinois River or the lower reaches of McGee's Creek. All prefer a firm substratum.

The terms, small river, middle-sized river, and large river, have been used previously by several authors when dealing with stream ecology. An exact definition of these terms is impossible; however, a large river condition could be described as the lower extremities of the large rivers which arise in Illinois, the Illinois River, and the great rivers bordering most of the state. A middle-sized river condition could be considered as a river less than 125 feet in width and usually wadeable. A small river is usually less than 50 feet in width and easily wadeable. The headwaters of a river include streams 15 feet or less in width and relatively shallow.

Other than several exceptions which will be mentioned later, the rest of the mussels are to be found equally in small and medium-sized rivers. Although occasionally found on a soft silt or mud substraum, this entire group demands a firm anchorage which may be composed of gravel, sand-gravel, or occasionally hard clay; however, there often is a thin layer of silt in contact with the shell. This group constitutes 29% of the population.

In Illinois, *L. recta* occupies only rapidly flowing streams of all sizes. It probably was found near *E. dilatatus.*

A. costata, T. truncata, P. coccineum, and *S. rugosus* are usually considered small river forms, although the latter two will descend considerable distances, while *A. costata* can often be found in the creeks which form headwaters of a river.

A favorite location for *L. anodontoides* is a firm substratum, slightly covered with silt, next to a steep bank, and in from two to five feet of water. This situation may well have existed at intervals while the stream flowed through the flood plain. *A. confragosus* probably occupied the same habitat; however, this mussel can be found in almost a completely soft substratum usually near rocks or other projections from the bottom.

A. ellipsiformes and *M. iris* are usually considered head-water forms, but often are found in rapidly running water, even in middle-sized rivers.

O. olivaria and *O. subrotunda* are never found in large numbers, and are scattered in middle- or large-sized rivers. They could have come from either the lower portion of

McGee's Creek or the Illinois River.

Several questions have arisen concerning the collection. In the community represented here, there should have been many more shells of *P. coccineum*. Present-day collections of mussels from river sites comparable to this one show that one mussel, *Lasmigona complanata* (white heel-splitter), must have been present. Why it was not in the collection is a matter for speculation. It must have been ignored for some reason; perhaps it was considered not palatable, or, perhaps, some taboo prevented its being taken from the water. Parmalee (1956) also found only four of this species among 1,934 valves representing several sites, which is a very untrue representation, as was the author's in light of comparable unionid communities as they exist today.

E. crassidens has been present in two of the sites studied from McGee's Creek. Its presence has not been recorded in Illinois during modern time. It prefers rapidly moving water with gravel substratum.

E. dilatatus was present in unusual numbers and alone forms 29% of the collection. As will be seen later, this fact is important in visualizing the edge of the flood plain as it must have existed at the time in question. This mussel is found where the current is strong and there is a firm substratum of gravel or gravel-sand. The author's largest present-day collection of this species was obtained where a small river was flowing rapidly down a gentle slope. Often 10 specimens could be gathered in one square yard of river bottom.

Today, McGee's Creek is a small stream, almost dry in the summer, and it flows between steep banks averaging 15 feet in height for at least 15 miles before it enters the flood plain of the Illinois River. Its original condition at two sites before it entered the flood plain has been reconstructed by the author (1953, 1958). At present, it meanders sluggishly through an almost level flood plain. Several beds, formed at various times since the Indians of the Chrisman site gathered clams, have been abandoned by the stream.

After examining the habitat- demands of those species in the collection which occupied McGee's Creek about 6,500 years ago, one can reconstruct the stream of that time from a point just previous to its union with the Illinois River. Its stream bed immediately before entering the flood plain was at least 20 feet higher than that of today. This has been indicated on an analysis of the Irvin site (1958). Upon leaving the higher land, the stream then flowed down a comparatively steep incline perhaps one-fourth mile in length to the flood plain; the inclined portion has since been carried downstream by the Illinois River forming the present-day bluffs. This assumption is verified by the unusual number of individuals of one species and the presence of several others which demand rapidly moving water, as would be true when the stream flowed down the inclined surface.

After the stream reached the flood plain, it must have approached the Illinois River with a definite current, without undue meandering, over a rather firm substratum of

gravel or sand-gravel, and with only a thin layer of silt covering the bottom near its junction with the Illinois River. It must have been comparable to a small to medium-sized river of today. An analysis of the habitat-demands of the other clams found in the stream support this opinion. All demand firm bottom and definite current. The complete lack of *Leptodea fragilis, Proptera laevissima, Anodonta corpulenta, A. gigantea,* and others which are usually found in a mud or silt substratum and slowly moving water also demonstrate the absence of this condition in it and the shallow areas of the Illinois River. The flood plain itself has probably changed little as shown by the fact that at least a portion of the deposit of shells, including many artifacts, was still present recently. The bluffs at the edge of the flood plain and the heavily silted areas in both the creek and river which are present there today have been formed in the last 6,500 years.

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NOTES ON THE LIFE HISTORY OF THE STEELCOLOR SHINER, *NOTROPIS WHIPPLEI* (GIRARD)

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The authors became interested in the steel color shiner (Fig. 1) because of its possible value as a commercial bait species. One is led to suspect its suitability for this purpose by: 1) the occurrence of dense populations in pond-like environments; 2) the shiner's tolerance to being handled in warm weather; and 3) its pronounced activity in aquaria.

During six years of collecting in southern Illinois, two well-established populations of the steelcolor shiner have been encountered. One of these occurs in Crab Orchard Lake; the other in the Big Muddy River. Crab Orchard Lake is a 7000-acre artificial impoundment. The Big Muddy River is a sluggish stream approximately 50 miles long with steep mud banks. The river ranges in depth from a riffle and pool stage in dry weather to a continuous stream 15 to 20 feet deep during the rainy season. Both populations are unusually dense. Seining in either of these waters in mid-summer will, on most occasions, produce a sizeable catch of the steelcolor shiner.

On numerous occasions collections of the shiner were transported and held in hot weather. The survival of the fish so handled was excellent.

On the negative side, the populations studied contained individuals that did not attain a size suitable for use as bait for the larger game fishes. Two inches is approximately the maximum size attained in the Illinois populations. Trautman (1957) reports individuals of 4.5 to 5.3 inches from Ohio. It also remains to be demonstrated that this species will prosper under hatchery conditions. Its native habitat suggests, however, that it would.

OBSERVATIONS

Age composition of Crab Orchard Lake population.— In studying the steelcolor shiner the authors concentrated on the age composition of the Crab Orchard Lake population. The most interesting information is that the steelcolor shiner has a life span of no more than two years.

Length-frequency plots of collections over a period of two years, and gonadal studies, indicate that the one-year-olds, which constitute the majority of a steelcolor shiner population, spawn in late August or early September, whereas the few two-year-olds which occur in a population spawn in July. In a collection of large specimens taken July 25, all were spent, but many smaller specimens taken in late August were still heavy with eggs. By October all fish were spent. In the winter following spawning the adults suffer heavy mortality. The young-of-the-year develop rapidly in the late summer or early fall.

The eight graphs of Figure 2 represent length-frequency distributions for particular dates. They give a more detailed analysis of the age

cycle. Figure 2, graph 1, shows two modes at 28 mm. and 42 mm. of standard length. The 28 mm. mode is interpreted as being composed of young-of-the-year. The second mode is of one-year-old fish, or fish spawned during the previous summer.

The distribution shown in graph 2 is essentially the same as that of graph 1. The length at which the first mode occurs is not quite as great as one might anticipate on the basis of the mode of graph 1, but the distribution of the first mode is skewed to the right and some variation is to be expected.

Graph 3 exhibits two modes corresponding to the 1953 and 1954 year classes. A third mode at 26 mm. of length is assumed to indicate spawning by older fish sometime during July, 1955.

Graph 4, based on collections taken in March, 1956, is not continuous with graph 3 inasmuch as the 1955 year class appearing on graph 4 is probably not fully represented on graph 3. Graph 4 may be compared with graph 2 which is based on a spring sample taken in 1955. This comparison is satisfactory with the exception that the 1956 fish appear to have grown faster than did the fish of the 1955 sample in graph 2. Growth data determined by use of the scale method will be presented to show that similar variations in growth rate are to be expected when comparing one year with another.

The length distribution shown in graph 5 is similar to the distributions shown in graphs 2 and 4. The samples shown in graphs 2 and 5 were taken at approximatey the same season but in different years. Graphs 5 and 6 show the same modes.

Graph 7 indicates the appearance of young-of-the-year in late August. These fish result from the early spawning of older fishes. The apparent great reduction in the older fishes in graph 7 is to be expected in a percentage plot, since the younger fish are relatively more abundant. If actual numbers present were compared with the June collection, one might find that the 1955 fish were still abundant.

Graph 8 includes a mode for young-of-the-year at 27 mm. of length and a prominent mode at 37 mm. representing the one-year-olds or the 1955 year class. The situation here is probably similar to that which existed in August, with the exception that the young-of-the-year of the 1956 class have been greatly decimated. Thus the 1955 year class, on a relative basis, again appears abundant.

Age and growth data determined by the scale method (Lagler, 1952: 99-127) for 75 steelcolor shiners taken from Crab Orchard Lake are shown in the upper tier of Table 1. The calculated standard lengths for the first and second annuli are 31 and 53 mm., respectively. This sample was collected in June, and compares favorably with the June sample treated in Figure 2, graph 6.

The middle tier of Table 1 is a compilation of age and growth data derived by the scale method from 17 steelcolor shiners selected from the fish collection of the Department of Zoology, Indiana University. The largest specimens were taken from collections of Dr. Shelby D. Gerking in order that more information might be gained concerning the age of large steelcolor shiners. The

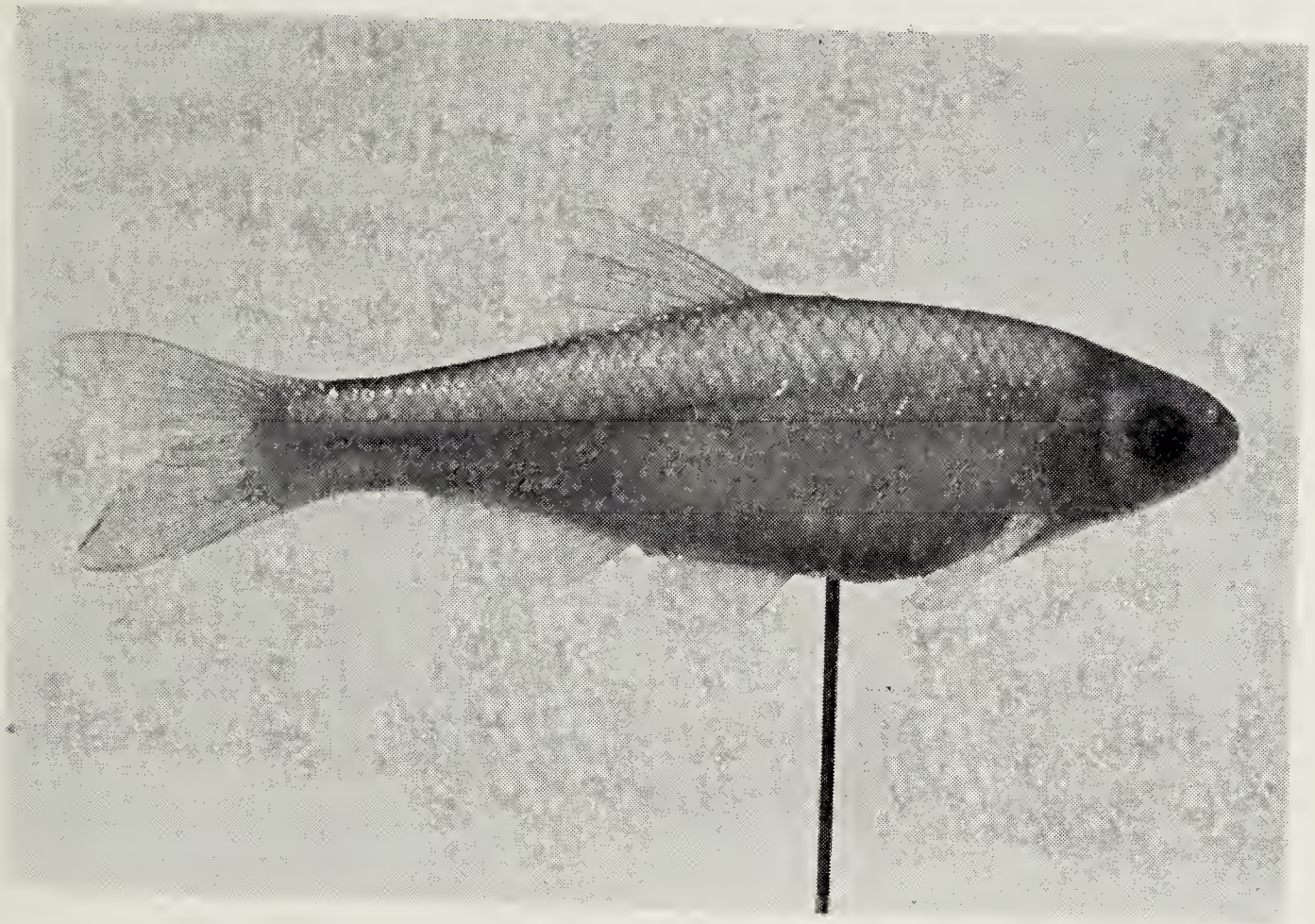


FIG. 1.—The steelcolor shiner, *Notropis whipplei* (Girard).

Indiana localities and numbers of specimens considered are: Eel River, 4; Bean Blossom Creek, 4; Sugar Creek, 4; Branch of Vermillion River, 2; Wabash River, 2; and East Fork of White River, 1. The oldest specimens were two years old. The calculated standard length for the second annulus was 53 mm., which is identical to the calculated length at the second annulus for the Crab Orchard Lake sample discussed above

The lower tier of Table 1 indicates that the growth of these fish was slower than that recorded for the steelcolor shiner, also by the scale method, for specimens taken in 1956 (Table 1).

Analysis of the data on scales leads one to the conclusion derived from a study of the length-frequency data, namely that the steelcolor shiner has a life span of no more than two years.

Parasites.—A well-established infestation of the tapeworm, *Ligula intestinalis* (identified by Dr. George Garoian, Southern Illinois University) appears in the Crab Orchard Lake population of the steelcolor shiner; of 51 specimens examined on July 23, 1955, 8 were found to contain a total of 18 immature tapeworms. Specimens of *Ligula intestinalis* four inches long were taken on a number of occasions.

A parasitic copepod of the genus *Lernea* was the only other parasite found to occur on the specimens collected in the present study. The infestation of *Lernea* was relatively light as compared with the infestation of this organism on associated species of fishes including the bullhead minnow, *Pimephales vigilax perspicuus*. The infestation on the bullhead minnow was some 10 to 15 times as severe as it was on the steelcolor shiner. Whether or not this dif-

TABLE 1.—Calculated and Measured Standard Lengths (in mm.) of Steelcolor Shiners.

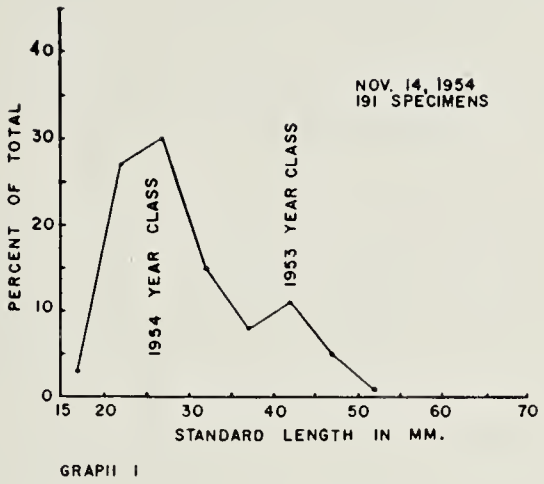
Age group	Number specimens	Average calculated length at each annulus		Length at capture
		1	2	
75 specimens, Crab Orchard Lake, Illinois, June 23, 1956				
0	12	..	..	44 (35-55)
I	59	30	..	53 (37-65)
II	4	32	53	63 (55-68)
Mean standard length	..	31	53	.....
Annual increment	..	31	22	.....
17 specimens, various Indiana localities				
I	2	23	..	65 (63-68)
II	15	22	53	74 (67-82)
Mean standard length	..	22	53	.....
Annual increment	..	22	31	.....
654 specimens, Crab Orchard Lake, Illinois, July 28, 1958				
I	584	19	..	37 (29-50)
II	70	19	37	52 (40-66)
Mean standard length	..	19	37	.....
Annual increment	..	19	18	.....

ference in degree of infestation was due to different habits of the fishes or a difference in the physiology or anatomy is, of course, difficult to establish. If the steelcolor shiner is resistant to *Lernea,* it would be in its favor in considering it as a bait species to be produced commercially; *Lernea* frequently constitutes a major problem in minnow hatcheries.

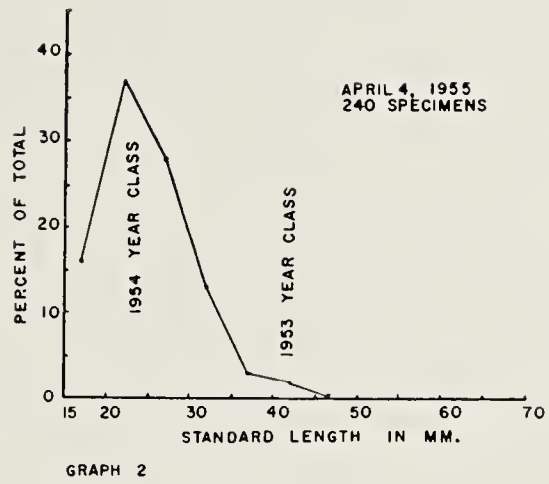
Ovarian counts and egg measurements.—Ovarian counts were made on 10 fish (42-51 mm. standard length) collected in July, 1956, to determine the total number of eggs in the ovaries. The counts varied from 610 to 1,308 eggs per fish. The average count was 1,049 eggs, corresponding to an average fish length of 46 mm. There was a fairly consistent positive correlation between egg count and length of the fish.

Twenty eggs from each of the 10 fish were measured. Average diameters varied from 0.47 to 0.66 mm.

Spawning.—Trautman (1957) observed about 30 steelcolor shiners spawning on the underside of a log raised about a foot from the gravel bottom of a stream. The females deposited their eggs on the underside of the log. In pond culture the steelcolor shiner would thus require a spawning board as do the fathead minnow, *Pimephales promelas,* and bluntnose minnow, *P. notatus.*



GRAPH 1



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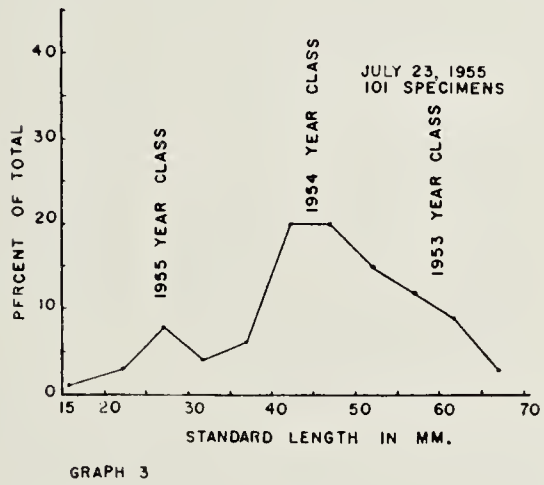

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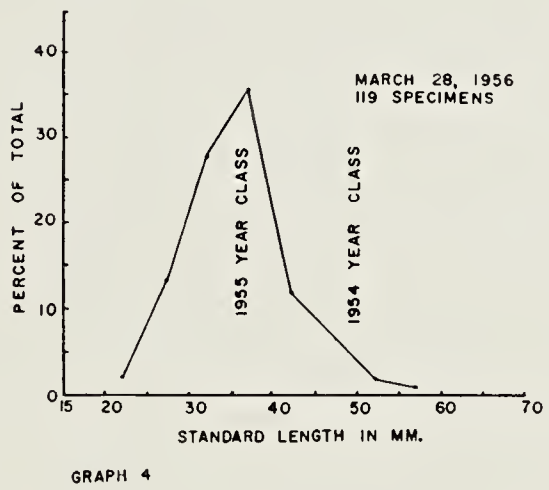

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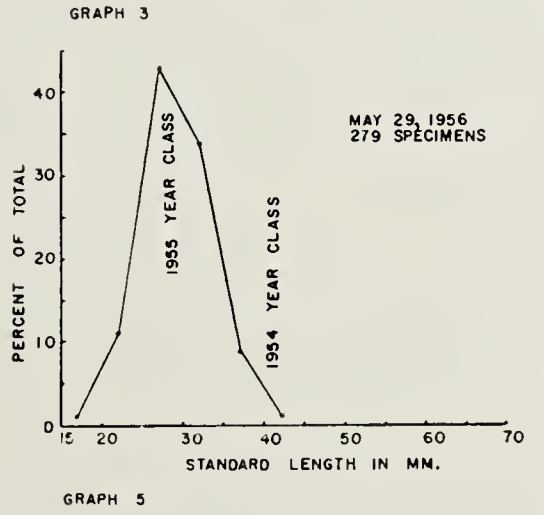

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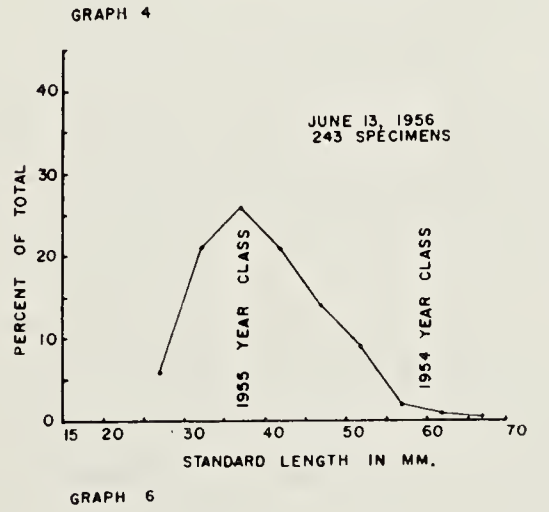

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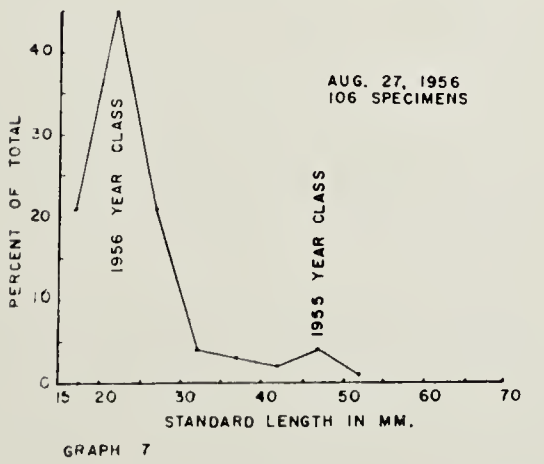

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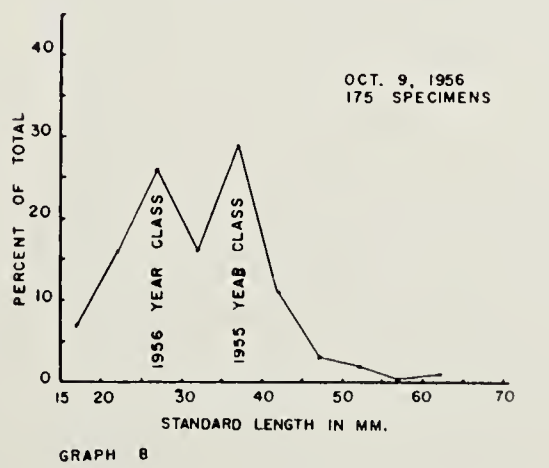

GRAPH 8

FIG. 2.—Length-frequency distributions for several collections of the steelcolor shiner from Crab Orchard Lake, Illinois.

Food analysis.—To arrive at some idea as to the food of the steelcolor shiner, 10 fish from each of the spring, summer, and fall collections were examined. All fish were adults ranging in size from 40 to 51 mm. of standard length. Among the spring specimens the identifiable material included five occurrences of terrestrial insect remains, one of algae, and one of entomostracans. In the summer specimens terrestrial insect remains were found in four individuals, insect larvae occurred in two and plant remains in two. In the fall collection insect remains occurred in two. From this limited amount of information it appears that the steelcolor shiner is primarily an insectivorous form.

Summary

1. The steelcolor shiner has a life span of no more than two years.
2. The maximum size attained by individuals from Crab Orchard Lake approximates two inches.
3. One-year-old fish spawn in late August or early September, whereas two-year-olds spawn in July.
4. Steelcolor shiner females contained an average of 1,049 eggs.
5. Spawning facilities for culturing the species should include spawning boards.
6. The steelcolor shiner is primarily insectivorous.

Acknowledgment

The authors wish to express their appreciation to Mr. Vernon Cole for preparation of the length-frequency graphs, and to Messrs. Darrell Louder, John Franklin, James Carter, Victor Renaud. and Robert Remmert, all of whom helped in making collections and observations on the steelcolor shiner.

This study was sponsored by the Cooperative Fishery Research Laboratory and Department of Zoology, Southern Illinois University, and by the Illinois Department of Conservation.

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Manuscript received May 1, 1959.

A NEW SPECIES OF CHIROTHRIPS FROM COLORADO (THYSANOPTERA: THRIPIDAE)

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Members of the genus *Chirothrips* are still imperfectly known in North America. In 1939 Andre gave an excellent synopsis of the species then recorded principally from the United States. For a period of three years thereafter, other species were described, two of which may prove to be synonyms.

Since 1941 no species of *Chirothrips* from North Americe has been described or analyzed except those from California (Bailey, 1957). Although there is a moderate amount of material in museum collections from the eastern and western parts of the United States, there is a paucity of specimens from the Great Plains, much of Canada, and almost all of Mexico.

Recently through the kindness of Dr. and Mrs. Herbert H. Ross, who often collect Thysanoptera to aid my studies, I have been able to examine many thrips from the Great Plains and the Rocky Mountain regions. The new species described herein was among their collections. I am most obliged to the Rosses for these specimens and to Miss Kellie O'Neill, U. S. National Museum, for the loan of critical material and for advice.

Chirothrips alexanderae new species

Female (macropterous).—Length distended, about 1.8 mm.; general color dark brown; antennal segment III light brown; tarsi yellow; wings yellow, lightly suffnsed with brown; body with red to orange subintegumental pigment scattered throughout as dots.

Head (Fig. 1) greatly produced in front of eyes; distance of vertex between fore margin of eye and base of antennae equal to or surpassing cheek margin from base of eye to posterior margin of head; vertex with faint elongate reticulations; posterior of dorsum of head with transverse striae; head setae few in number; each interocellar seta arising close to eye margin, placed slightly forward of fore ocellus; ocelli present; antennal segment I not greatly enlarged; segment II drawn out at outer apex into sharply pointed tip with seta placed just below tip, and with outer margin seemingly ridged or more heavily sclerotized than remainder of segment; segment VI not longer than segments IV and V combined.

Pronotum moderately long; transverse straiae, only moderately setose; setae slender, with two pairs of prominent posterolateral setae. Prosternum lacking setae. Mesonotum transversely striate, without scallops. Meso- and metanotum with only the normally few pairs of setae. Meso- and metasternum with relatively few setae. Fore wings fully developed.

Abdominal tergites with sculpture in form of transverse striae, without scallop-like markings. Abdominal sternites with transverse striae usually broken into scallop-like sculpture; posterior margin with distinct toothlike projections laterally, straight medially. Abdominal segment X pointed and nearly twice as long as abdominal tergite IX.

Male.—Unknown.

Holotype. — Female, Green Mountain Falls, Colorado, June 16, 1954, Ross and Ross, in grassland. *Paratype.*—1 ♀, Ellicott, Colorado, July 11, 1956, Ross and Ross, in grass mixture.

These types are deposited in the collection of the Illinois Natural History Survey.

A closely related form, if not a variety of the same species, is repre-

Fig. 1.—*Chirothrips alexanderae* new species. Head and prothorax, dorsal aspect.

sented before me by a single specimen from south of Thedford, Nebraska, collected by Dr. R. A. Evers and myself on June 22, 1957, from a hillside prairie. In this specimen, antennal segment II is slightly shorter than that of the types; abdominal segment X is only just slightly longer than abdominal tergite IX; and the abdominal sternites have the transverse striae more continuous and less broken up into scallops. Until more is known about the range of variation in the populations from Colorado and Nebraska it is not possible to draw a sound conclusion on the taxonomic status of the Nebraska specimen.

The North American species which most closely resembles *C. alexanderae* is *C. praeocularis* Andre. In *praeocularis* antennal segment II is more decidedly produced than that of *alexanderae* (Compare Fig. 1 in Andre, 1941, and Fig. 1 in this paper.) and the abdominal sternites usually lack strong toothlike fringes along the posterior margin. In *alexanderae* these toothlike projections are conspicuous along the lateral margins of the abdominal sternites.

The species, *C. productus* Hood, which is found in the same general region as *alexanderae,* has the head only moderately produced (See Fig. 3, plate XIV, in Hood, 1927.) and probably is a member of the *manicatus* complex rather than of the *praeocularis* — *alexanderae* group. *Chirothrips frontalis* Williams from Argentina is similar in head characteristics, at least, to *alexanderae,* but these two species can be distinguished by the placement of the ocellar setae.

This species is named in honor of Mrs. Ruth Alexander, at whose summer home the collectors, Dr. and Mrs. Ross, were guests.

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Manuscript received April 28, 1959.

EFFECT OF ENZYMES ON INFECTION OF BEAN LEAVES BY TOBACCO MOSAIC VIRUS, *MARMOR TABACI*, H.

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This paper is a continuation of a study on the effect of some compounds and biological products upon infection by tobacco mosaic virus. The previous study by Dale and Thornberry (1955) reported the findings from investigations on eight groups of substances and biological products (dyes, amino acids, polypeptides, proteins and protein derivatives, nucleic acid derivatives, plant growth substances, miscellaneous substances, and enzymes.) Since 13 of the 16 tested enzymes inhibited or reduced the amount of infection at some pH, it seemed worthwhile to ascertain the effect of many other enzymes on infection. The results of such an investigation are reported and discussed.

Review of Literature

Literature in addition to the previous paper by Dale and Thornberry (1955) has been reviewed by Bawden (1954).

Materials and Methods

The enzymes used were commercial preparations purchased from the Nutritional Biochemicals Corporation. They were tested at 0.1% concentration in the inoculum unless otherwise stated. Snake venom from the western rattle snake, *Crotalus atrox,* and obtained from the Ross Allen Company, was tested at concentrations indicated in tables.

The buffer system was 0.1 M sodium phosphate; NaH_2PO_4 for pH 4.5, 1:9 mixtures of 0.1 M Na_2HPO_4 and NaH_2PO_4 for pH 6.0, and Na_2HPO_4 for pH 8.5. The solutions were adjusted to the desired pH with 1.0 NHCl or NaOH.

The virus was a subculture of tobacco mosaic virus, *Marmor tabaci* var. *vulgare* Holmes, Johnson's strain No. 1, secured from W. C. Price in 1938 and maintained in living plants of Turkish (Samsun) tobacco, *Nicotiana tabacum* L. Partially purified preparations of the virus were used at a concentration to provide about 50 lesions per leaf from inoculations with nontreated virus.

Assays for most of the tests were on primary leaves of 12- to 14-day-old Scotia beans, *Phaseolus vulgaris,* L. However, Pinto beans were substituted while we were restocking with seed of a satisfactory strain of Scotia bean. Opposite leaves were inoculated with treated and nontreated virus and washed with tap water soon after the application of virus by stroking the upper surface of the leaves with a cheesecloth pad moistened with the inoculum. Ten half leaves were inoculated with each inoculum.

Experiments and Results

The influence of some additional enzymes and similar substances on infection was ascertained at three

TABLE 1.—Effect of Enzymes and Related Substances on Infection of Primary Leaves of Bean by Tobacco Mosaic Virus in 0.1 M Sodium Phosphate Buffer. (Concentration at 0.1% except where noted.)

Substance	Infection index at		
	pH 4.5	pH 6.0	pH 8.5
Enzymes:			
Acetyl cholinesterase	0.88	1.13	0.015
Acid phosphatase	0.02	0.00	0.00
Alcohol dehydrogenase	0.76	0.76	0.66
Aldolase	0.40	0.64	0.74
Alkaline phosphatase	0.00	0.00	0.00
D-amino acid oxidase	0.00	0.00	0.00
Amylopsin	0.07	0.01	0.01
Arginase	0.29	0.53	0.03
Carbonic anhydrase	0.85	0.74	0.043
Carboxylase	0.45	0.33	0.32
Carboxypeptidase	0.34	1.17	0.81
Carnosinase	1.08	0.77	0.11
Chymotrypsinogen	0.00	0.00	0.00
Desoxyribonuclease	0.59	0.63	0.31
Emulsin	0.01	0.02	0.04
Erepsin	0.02	0.00	0.001
Ficin	0.02	0.005	0.008
Fumarase	0.77	1.40	3.8
B-glucosidase	0.66	0.67	0.105
Glyceraldehyde phosphate dehydrogenase	0.65	0.72	1.22
Hexokinase	0.17	0.03	0.009
Invertase (mellibiase free)	0.01	0.02	0.02
Lactic acid dehydrogenase	1.00	0.95	0.27
Lipoxidase	0.44	0.44	0.57
Malic acid dehydrogenase	0.76	0.56	1.41
Mylase P	0.02	0.04	0.004
Pancreatin	0.07	0.06	0.01
Papain crystalline 2x	0.48	0.056	0.004
Pectin esterase	0.28	0.10	0.14
Penicillinase	0.71	0.86	0.78
Pepsin	0.67	0.18	0.32
Pepsinogen	0.04	0.02	0.005
Peroxidase (horseradish)	0.04	0.03	0.01
Protease	0.00	0.00	0.30
Proteinase	0.09	0.08	0.09
Rhodanase	0.00	0.02	0.02
Ribonuclease	0.00	0.00	0.00
Trypsinogen	0.008	0.0008	0.00
Tyrosinase	2.15	1.14	0.10
Uricase	0.05	0.03	0.02
Xanthine oxidase	1.82	0.57	0.22
Cytochrome C	0.03	0.08	0.15
Di-(p-chlorophenyl)-phosphoryl chymotrypsin	0.00	0.00	0.00
Properdin, 10 units per ml	[a]	.....	0.00
Snake venom, 0.01%	.....	.....	0.00
Snake venom, 0.01% boiled for 10 minutes	.....	.....	0.00
Triphosphopyridine nucleotide	0.59	0.80	1.28
Trypsin inhibitor, Lima bean	0.30	0.37	0.29

[a] No t. st.

TABLE 2.—Effect of Concentration of Venom from *Crotalus atrox*, on Infection of Primary Leaves of Bean by Tobacco Mosaic Virus and on the Virus at 22°C. and pH 7.0 for 60 Minutes. (Assay of virus in 0.1 M sodium phosphate buffer at pH 8.5.)

Venom concentration, %	No. lesions per leaf	
	0 minutes	60 minutes
0.5	0.0	0.0
0.1	0.0	0.0
0.01	0.0	0.0
0.001	6.8	1.0
0.0001	15.5	22.6
None	42.6	60.5

H-ion concentrations. The assay plants were inoculated within 30 minutes from the time of mixing the viral suspension and the solution of enzyme or substance. In Table 1, the infection indices, each a ratio of the number of lesions from the treated virus to that from the nontreated virus, show that 21 of the 41 enzymes strongly inhibited infection at all three H-ion concentrations. Properdin and boiled and nonboiled snake venom were tested only at pH 8.5; they inhibited infection. Five enzymes inhibited or reduced the amount of infection at one or two H-ion concentrations. Trypsin inhibitor, triphosphorpyridine nucleotide, and 13 enzymes had little or no effect on the amount of infection. Tyrosinase at pH 4.5 and fumarase at pH 8.5 increased the amount of infection. Infection indices between 0.5 and 1.5 are probably within the experimental error since the results are from one test.

The influence of the concentration of snake venom in the inoculum on infection was determined by mixing the venom and virus just prior to inoculation. To detect any action of enzymes in the venom on the infectivity of the virus, samples of the virus-venom mixture were adjusted to pH 7.0 and incubated at 22°C. for 60 minutes, then adjusted to pH 8.5 for inoculation. The results given in column 2 of Table 2 show that the venom is a strong inhibitor of infection. Even as little as 0.0001% inhibited infection about 40%; 0.001% about 83%. The results listed in column 3 of Table 2 indicate no action of the enzymes in the venom on the infectivity of the virus, since the amount of inhibition was about that from the venom without incubation.

DISCUSSION AND CONCLUSION

Strong inhibition by many of the enzymes tested confirms the earlier report by Dale and Thornberry (1955) that enzymes of different specificities inhibit infection. Under these conditions it seems unlikely, therefore, that specific and generally recognized enzymatic reactions of a chemical nature are involved in the mechanism of inhibition. Nonspecific physical alteration of the surface of virus or the injured cell seems likely. The inhibition is surely physical in nature, since enzymatic chemical reactions are excluded. Since all enzymes tested do not inhibit infection and since the proteins in casein, skimmed milk, and beef blood serum do inhibit infection (Dale and Thornberry, 1955), the inhibiting proteins and enzymes probably have some particular physical property which accounts for the inhibiting

action. Proteins are surface active and adsorb to sites of surfaces with appropriate electrical charge; therefore, the mechanism may be one involving surface interactions between the inhibiting protein and the virus, the injured cell, or both, although the data do not indicate which component might be involved. Thus, inhibition of infection by enzymes may be due to a competitive mechanism in which the inhibiting protein competes with the viral nucleoprotein for the surface of the injured cell or with the substances on the surface of the injured cell for the viral nucleoprotein. If nucleic acid is released from the viral protein for infection, the inhibiting protein might protect the viral particle and thus prevent the separation of nucleic acid for subsequent infection.

It is of interest that properdin, a protein of blood serum, inhibits infection since it protects animals against viral infections (Pillemer *et al.*, 1954) and interacts with polysaccharides on the surface of cells (Pillemer *et al.*, 1955). Likewise it is of interest that a specific protein on the surface of cells of one mating strain of a heterothallic yeast interacts with a complementary polysaccharide on the surface of cells of the opposite mating strain in the primary union of the two cells (Brock, 1959).

Snake venom, which contains several enzymes, strongly inhibited infection. Since boiling an aqueous solution of the venom for 10 minutes did not destroy the inhibitive property of the venom, either the enzymes are resistant to the treatment or stable substances other than enzymes in the product inhibited infection. However, such enzymes as chymotrypsin may be reactivated upon cooling after being boiled (Northrup, 1939). Substituted chymotrypsin, di-(p-chlorophenyl)-phosphoryl chymotrypsin, also inhibited infection strongly.

Increase in the amount of infection from two enzymes, fumarase at pH 8.5 and tyrosinase at pH 4.5, but inhibition at pH 8.5, also appears to be associated with properties other than enzymatic activity, since the favorable pH for activity of these enzymes, fumarase pH 6.6 (Spector, 1956) and tyrosinase pH 5.5-7.0 (Spector, 1956), is not the pH at which increased infection occurred.

Summary

The data support the conclusion that enzymes inhibit infection by a mechanism other than their catalytic chemical action on specific substrates. It is conjectured that a particular physical mechanism, probably surface interactions, is involved.

Acknowledgments

1. These studies were aided by a contract between the Office of Naval Research, Department of the Navy, and the University of Illinois, NR 131-193.
2. The studies, in part, were conducted by the junior authors in connection with a graduate research course in plant pathology.
3. Properdin was supplied by the late Louis Pillemer (private commun.) November 16, 1955.
4. Substituted chymotrypsin, di-(p-chlorophenyl)-phosphoryl chymotrypsin was provided by A. K.

Balls (private commun.) January 16,1957.

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ROTATORY DISPERSION AND ABSORPTION STUDIES ON DICHLORO *BIS*-PROPYLENEDIAMINE COBALT(III) CHLORIDE

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Mundelein College, Chicago

Introduction

The symmetry found in certain coordination compounds which results in their optical activity has been a subject of investigation since the early work on these complex molecules by Werner (1911:2445). Previous to that time it was thought that an asymmetric carbon atom in a molecule was necessary for optical rotation. Absolute, or total, asymmetric synthesis is now a well established fact and can be used to advantage in a number of ways.

Ordinary asymmetric synthesis involves the use of optically active reagents but without the use of any of the known methods of resolution. In this case the ligands themselves are optically active. When the ligands in coordination compounds are optically active, only certain preferred stereoisomeric modifications are found, rather than all theoretically possible forms. Stereochemists have made a study of this phenomenon and found the problem an intriguing one.

The compound, dichloro *bis*-propylenediamine cobalt (III) chloride, is one in which one of the ligands is optically active. It is analogous to

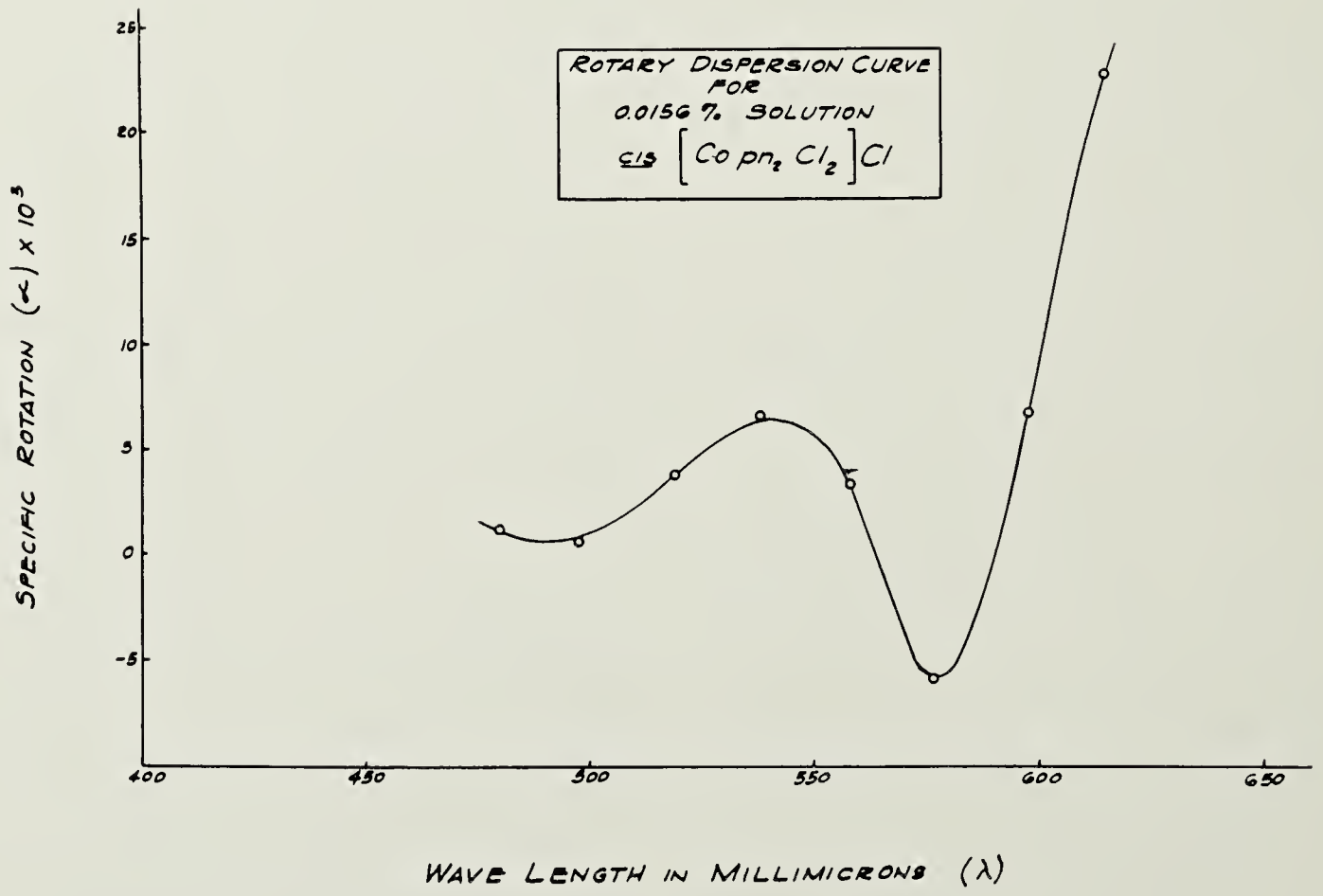

FIGURE 1.

the first coordination compound resolved by Werner, [Co $en_2(NH_3)$ Cl] Br_2, but has the ligand propylenediamine which is itself resolvable. For the first step in our study of the complex, which is presented here, *racemic* propylenediamine was used to obviate the problems which might arise from the activity of the ligand.

Experimental

Rotatory dispersion and absorption studies were carried out on *cis* (Co pn_2Cl_2)Cl which was prepared in the laboratory according to the method of Werner and Fröhlich (1907:2225) as modified by Bailar and co-workers (1939:2402) and later further modified by Martinette, *et al.* (1955:6507).

Optical activity measurements were taken across the spectrum at 25° C. using a Fric polarimeter accurate to 0.01° and a Thermionic quartz monochromator, model B, through which light from a carbon arc lamp was passed. Solutions of 0.05%, 0.025%, and 0.0156% concentrations of the complex were used. These solutions are highly colored and duplication of readings was more successful with the solution of 0.0156% concentration. Since the molecule aquates in a moderately short time it was necessary to take readings immediately upon solution of the compound. The more dilute solution permitted more rapid reading of the instrument. Figure 1 gives the rotatory dispersion curve obtained by plotting the specific rotation, $[\alpha]^{25°}_{\lambda}$, versus the wave length, λ.

Absorption data were taken on solutions of the same compound and across the same range of the spectrum. A Coleman Universal Spectrophotometer, model 14, was used and a concentration of 0.5% appeared to give optimum results. The ex-

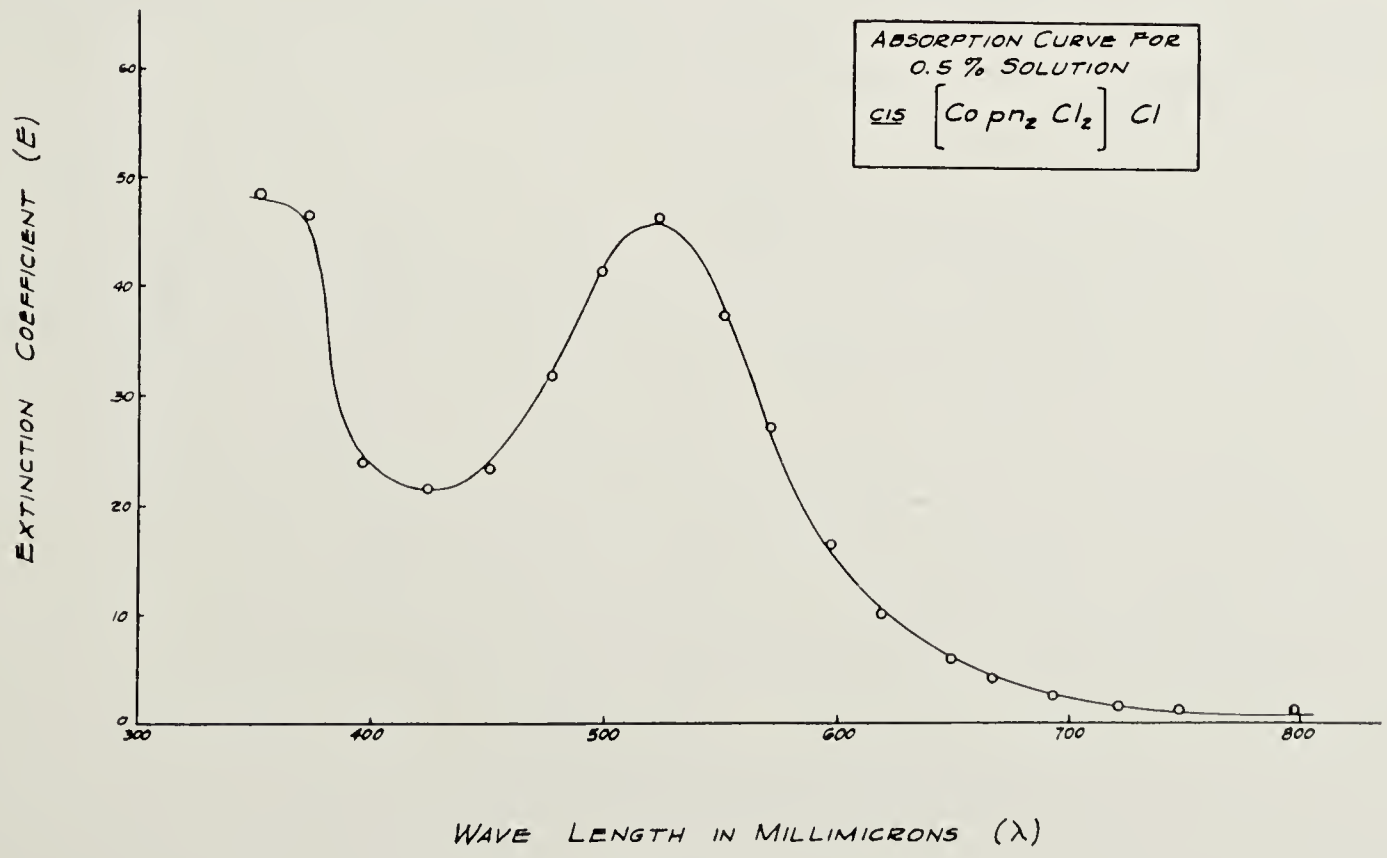

Figure 2.

tinction coefficients (E) were determined and the plot of E versus the wave length, λ, was drawn (Fig. 2).

Discussion and Summary

The rotatory dispersion of an optical isomer and a phenomenon known as circular dichroism or the "Cotton effect" are believed to be closely related. Dichloro *bis*-propylenediamine cobalt(III) chloride has the general formula $[M(AA)_2a_2]a$ in which M is the metal ion, A is a bidentate ligand and a is a monodentate ligand when written within the brackets. The ion $[M(AA)_2a_2]^+$, which in this case is $(Co\ pn_2\ Cl_2)^+$, may have the two possible spatial arrangements shown in Figure 3. It is therefore postulated to have two structures which are diastereoisomers. The configurations of the ions are seen to be non-superimposable mirror images and should be, and have been found to be, optically active. A method of separation, while probably possible, has not been found as yet.

Cotton showed the rotatory power of a molecule to increase strongly as one approaches an appropriate absorption band and to change sign within the region of absorption. He showed, too, that only an "optically active band" will exhibit this anomalous dispersion of rotatory power. This light absorption within an optically active band is different for the *d*- and the *l*- components. The effect is called circular dichroism. The superimposition of the rotatory dispersion curve on the absorption curve of the compound studied here is shown in Figure 4 where the effect is immediately apparent.

The data, then, obtained in this experiment, would seem to verify the presence of two optically active forms of the compound. Throughout this work it was assumed that by using *racemic* propylenediamine in the preparation of the complex molecule, the coordination compound, no activity resulted merely from the ligand. The optical activity of the ligand may, and may not, influence the total activity. That remains to be determined.

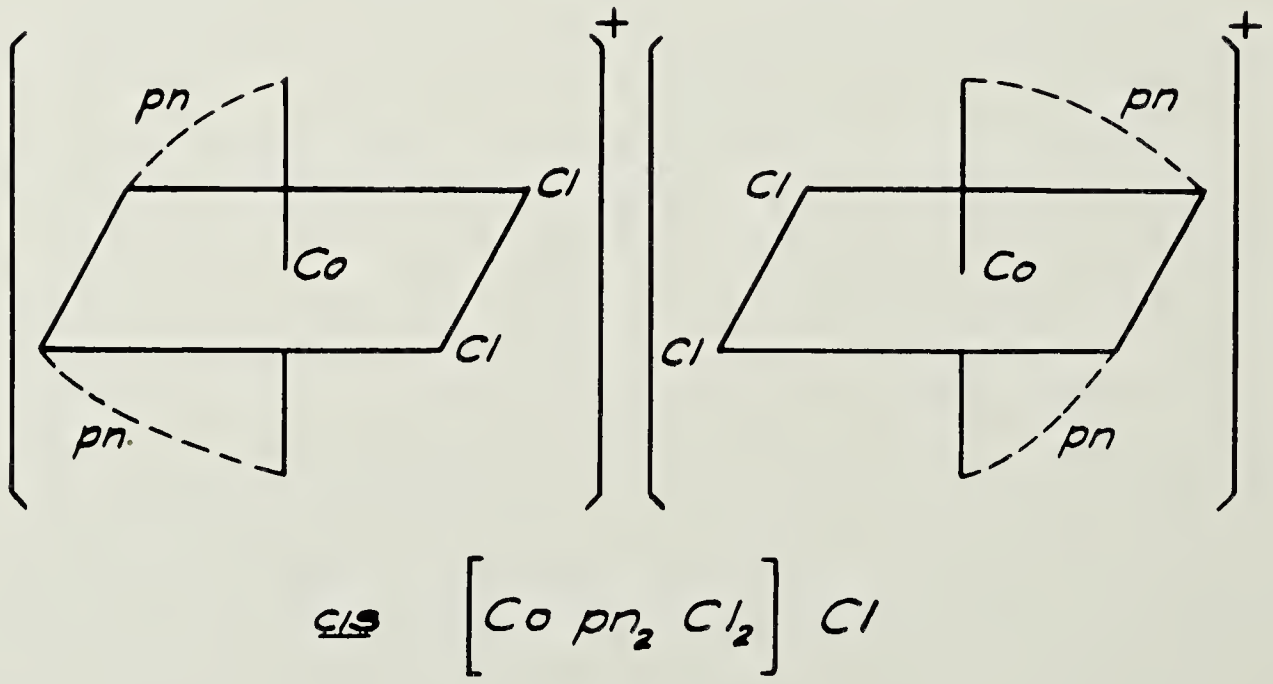

Figure 3.

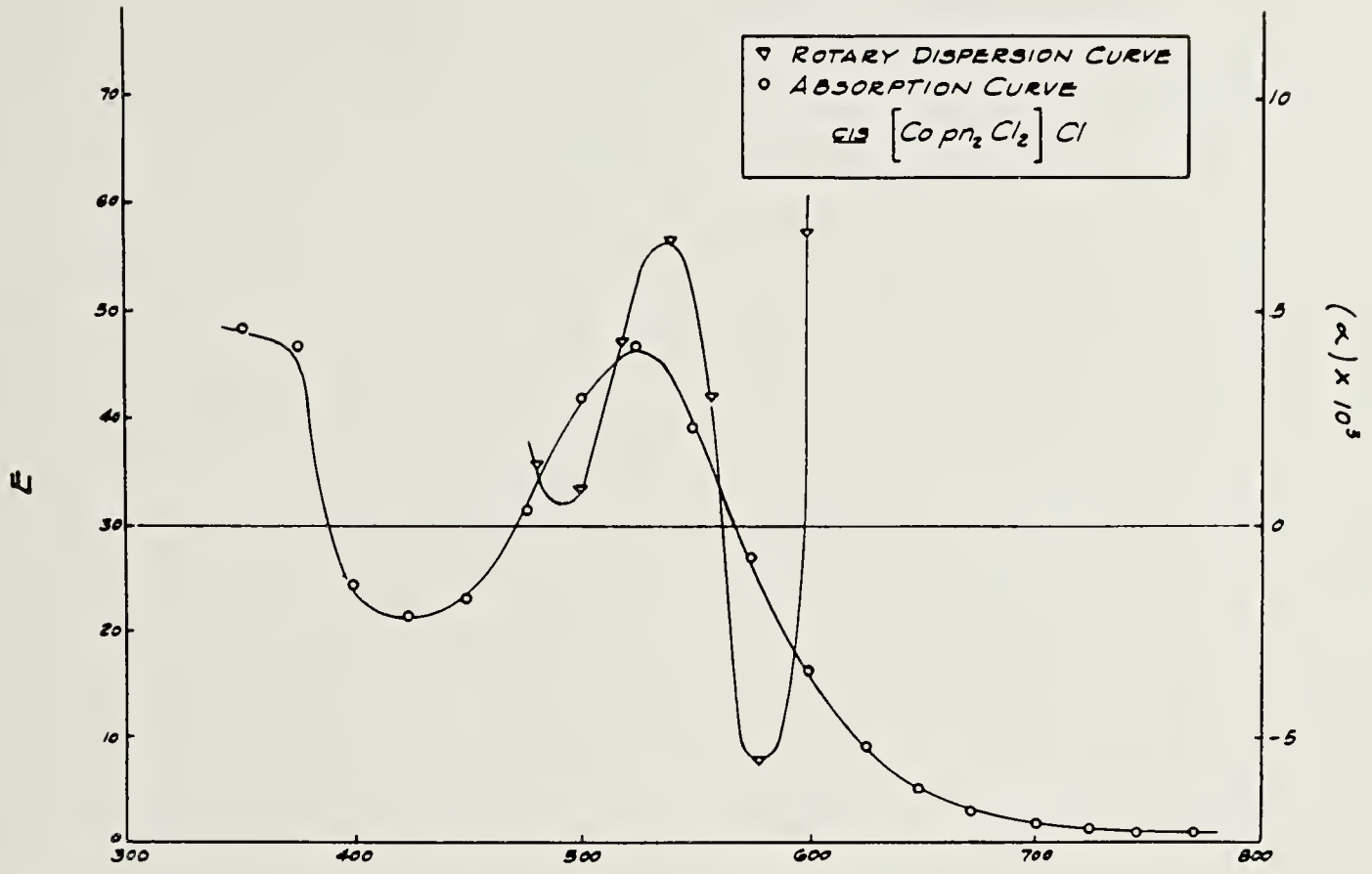

FIGURE 4.

ACKNOWLEDGMENT

We have received financial assistance and encouragement from Research Corporation, the National Science Foundation, Sigma Xi, and from the Illinois State Academy of Science. The investigators are grateful to the Academy for its contribution to their work.

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Manuscript received February 2, 1959.

ACADEMY BUSINESS

SECRETARY'S REPORT FOR THE YEAR MAY 10, 1958 - APRIL 24, 1959

ROBERT A. EVERS, *Secretary*

The 52nd Annual Meetings of the Illinois State Academy of Science were held at Chicago, Illinois, on April 24 and 25, 1959, with the Illinois Institute of Technology as host. The program of the 11 sections included 94 papers and the total attendance at the section meetings was more than 400.

The general session of Friday morning, April 24, held in Siegel Hall Auditorium, opened with a Welcome by Dr. J. T. Rettalliata, President of the Illinois Institute of Technology. This was follow by the Presidential Address of Dr. Harlow B. Mills on "The Importance of Being Nourished."

At 10:50, Dr. John Marberger, Director of Research, Aeromedical and Physical Environment Laboratory, University of Illinois, Chicago, gave a very interesting and informative lecture on "Recent Concepts and Medical Problems Occasioned by Space Flight."

The annual banquet was held in the Lower Lounge of the Commons Building. The evening public lecture, held in the Chemistry Building Auditorium, was given by Mr. Frank C. Bellrose, Game Specialist, Illinois Natural History Survey. He spoke on "The Orientation Ability in Birds." In his lecture Mr. Bellrose explained some of the most recent advances in the study of migration in birds.

Council Meetings

The Council held four meetings during the year. The first meeting was held in Room 211, Illini Union, University of Illinois, Urbana, Illinois on May 10, 1958.

Dr. Lindbeck, Chairman of the Junior Academy, reported that 976 exhibits were judged by approximately 400 judges and that 93 exhibits were considered outstanding. Dr. Lindbeck also reported that 1,200 attended the Junior Academy banquet, the largest banquet ever served at the University of Illinois.

Dr. Neckers submitted the proposed budget for 1958 to 1959 which was approved after several modifications.

The Council appointed Dr. Harvey I. Fisher, Southern Illinois University, as Editor and Mr. James S. Ayars, Illinois Natural History Survey, as Publicity Adviser for the next year.

To conform to the By-Laws as amended in the 51st annual meeting, Dr. Wantland made a motion, seconded by Mr. Bamber, that the Committee on Publications be dissolved. The motion carried. There followed a discussion concerning members for the new Board of Editors but action upon this was deferred and members will be approved by mail vote of the Council.

Dr. Mills reported the following members now serve on the Board of Editors: F. O. Green, Wheaton College; Reece Jones, Western Illinois University; John McGregor, University of Illinois; Paul Silva, University of Illinois; Francis Kruidenier, University of Illinois; George Ekblaw, State Geological Survey; Neil Hardy, Lincolnway Community High School; Milton Thompson, Illinois State Museum.

Upon a motion made by Mr. Bamber, seconded by Dr. Welch and passed by the Council, the President and Secretary were empowered to obtain meeting places for 1959 and for 1960 and to choose the Second Vice-President for the 1959 meeting.

The second meeting of the Council was held in the Dome Room, Hotel Saint Nicholas, Springfield, Illinois, on November 1, 1959, with 14 persons attending. Dr. Mills presided.

In accordance with the wishes of the Junior Academy the Council agreed not to give separate Outstanding Award Certificates but to affix to the regular Certificate of Award a special seal which states that the certificate is one of an Outstanding Award. The Council also accepted the recommendations of the Junior Academy concerning the Frank Reed Awards. The Council instructed the Science Talent Search Committee to make recommendations and report back to the Council at its next meeting.

Dr. Evers announced the 52nd Annual Meeting would be held on April 23, 24, and 25, 1959, at the Illinois Institute of Technology, Chicago, and that Dr. Leslie Hedrick had been appointed Second Vice-President. Dr. Evers also reported that the invitation from Father Julian Woods, Quincy College, had been accepted and that the 53rd Annual Meeting would be held at Quincy College, Quincy, Illinois, on April 28, 29 and 30, 1960.

Dr. Kanatzar reported on a meeting held October 18 in which plans were laid for contacting industry for help in financing the Junior Academy program. A special committee composed of Dr. Lindbeck, Dr. Thomas, Dr. Kanatzar, Dr. Mills, Mr. Hardy, Mr. Thompson, and Dr. Evers was formed to deal with these special problems of the Junior Academy.

Dr. Evers moved, seconded by Dr. Kanatzar, that Miss Elnore Stoldt and Dr. Walter B. Welch be appointed delegates to the A.A.A.S. and to the Academy Conference. The motion carried.

A letter from Dr. Hurst Shoemaker which explained the need for a Conservation Section and petition for such a section, which had been signed by more than the required number of members, were read by the Secretary. Dr. Wantland moved that a Conservation Section be formed. The motion, seconded by Dr. Levine, carried. Dr. Evers moved that the appointment of Dr. Robert Bullington as Chairman of the newly formed section be confirmed. The motion, seconded by Dr. Welch, carried.

A petition from 11 members of the Archeology and Anthropology Section was read by the Secretary. These members petitioned the Council to change the name of the section to read "Anthropology Section" and gave valid reasons for making this change. This revision in name would not change the organization, functioning nor subject matter of the section. Dr. Levine moved that this change be made. The motion, seconded by Dr. Kanatzer carried.

The third meeting of the Council was held in Room 485, Natural Resources Building, Urbana, Illinois, on February 7, 1959, with Dr. Mills presiding. Nineteen persons attended this meeting. Dr. Lindbeck reported on the formation of two new districts in the Junior Academy—the one containing the Chicago Public Schools, the other Catholic Schools in Chicago. Dr. Lindbeck reviewed the proposed program for the May meeting of the Junior Academy and called attention to the Saturday morning session in which Junior Academy members would present papers. He asked that Academy members attend these sessions to help select persons for awards for the best presentation of papers.

Dr. Hedrick told of the work that had been done at the Illinois Institute of Technology for the coming annual meetings and that further preparation must await the beginning of the second semester.

Dr. Levine informed the Council that the Collegiate Section this year will have a round table or panel discussion on "The Effect of Science on World Politics." He further suggested that undergraduates who wish to submit papers should do so in the regular sections of the Academy. These plans were accepted by the Council.

Dr. Yohe gave the report of the Science Talent Search Committee. This report concerned the Frank H. Reed Memorial Fund Awards. The following recommendations of the committee were approved.

1. That efforts be made to increase the principal amount of the Frank H. Reed Memorial Fund as rapidly as possible to an amount capable of yielding at least $50.00 per year in interest, either through allocating funds now being received as Sustaining Membership dues, or through obtaining additional gifts specified for this purpose.
2. That until such time as this goal is attained, the Council allot to the Science Talent Search Committee the additional amount of $100.00 per year, of which $50.00 is to be used for the current award or awards, the remainder to be added to the principal until that principal reaches the size specified in paragraph No. 1.
3. That the Frank H. Reed Memorial Award winner or winners shall be selected each year by the Science Talent Search Committee from the lists of those honored by the Illinois State Academy of Science as Illinois Winners, *i.e.*, those listed as National Winners, National Honorable Mentions, and State Honorable Mentions, in the Westinghouse Competition.
4. That the awards shall be made on the basis of the Project Reports submitted in the Westinghouse Con-

test. The Committee shall consider clarity of thought and expression and correctness of spelling and grammatical construction as well as soundness of scientific principle.

5. That at the discretion of the Committee the Award shall go to the one student whose report is adjudged best, may be divided so that two or three students share the Award, or may be withheld if no report of suitably high quality is found.
6. That the first Award shall be made in the spring of 1959, and shall be in the amount of $50.00 derived from interest on the principal of the Frank H. Reed Memorial Fund augmented by money from that assigned to the Science Talent Search Committee in the current budget.

Dr. Kanatzer outlined the work of the Junior Academy *Ad Hoc* Committee and the Chicago Committee of Industry. The budget was tentatively set at $15,000 and the State Committee should now be formed to obtain these funds.

Dr. Kanatzer reviewed requests for the history of the academies and introduced Dr. Hendrickson of MacMurray College who is interested in writing a History of the Illinois Academy of Science. Dr. Hendrickson outlined his proposals for a two-year program and felt it would require about $300.00. Council members suggested Dr. Hendrickson should apply for a Research Grant to obtain this sum.

The Fourth meeting of the Council was held Thursday evening, April 24, 1959, in the Executive Conference Room, Student Union, Illinois Institute of Technology, Chicago, Illinois. Preliminary reports were presented by the officers, committee chairmen, and section chairmen. Final reports were presented at the annual business meeting on Friday, April 24, 1959.

Annual Business Meeting

The business meeting of the 52nd Annual Meetings of the Illinois State Academy of Science was held April 23, 1959, in Siegel Hall Auditorium, Illinois Institute of Technology, Chicago, Illinois, at 5:00 p.m., with President H. B. Mills presiding.

The report of the Secretary, which follows, was seconded by Dr. Welch and accepted.

The minutes of the 51st Annual Meeting, held in the Auditorium, University of Illinois, Urbana, were published in Volume 51 of the *Transactions*. Mimeographed copies have been prepared and distributed in this meeting. The minutes include the actions of the Council and the reports of the standing and special committees.

Activities of the Academy have been summarized in the President's Annual Letter, which, with the program of the 52nd Annual Meeting, was mailed to each member on the Secretary's mailing list as of March 15, 1959.

Mr. President, I move the acceptance of the report of the 51st Annual Meeting as mimeographed and also the summary of the year's activities as indicated in the President's Annual Letter.

Dr. Welch, Treasurer, presented an interim report. He moved the acceptance of the report. Dr. Levine seconded and the motion carried.

Dr. Levine reported that the round table discussion in the Collegiate Section was very successful and a great deal of interest was shown both by the panel members and those attending the session.

Reports of Standing Committees

Animal Experimentation in Research.—Dr. Kaplan reported for this committee. Dr. Ekblaw moved the report be accepted and that the recommendations of the committee be referred to the new Council for study. The motion, seconded by Dr. Levine, carried.

Budget.—Dr. Welch stated that the Committee had prepared a tentative budget for 1959-1960 but revisions were needed. The Council in its meeting on Saturday, April 25, 1959, should make the needed revisions.

Conservation of Archeological and Historical Sites.—Mr. Milton Thompson discussed the Archeological Conservation Law, a bill which is proceeding through the preliminary stages in the General Assembly.

Membership.—Mr. Boewe summarized the work of this committee in 1958 and 1959 and announced a fair increase in the membership in the past year. Mr. Boewe moved that persons who have applied for membership during the past year and have met the qualifications be elected to membership. The motion, seconded by Dr. Welch, carried.

Research Grants.—Dr. Shaffer reported that the Committee recommended the following grants.

Richard C. Anderson, $100.00; B. J. Jaskoski, $150.00; Sister M. Benita, $150.00; Leo Schatz, $100.00; W. B.

Hendrickson, $300.00 for a 2-year period provided certain recommendations and stipulations of the committee are met.

Dr. Shaffer moved the acceptance of the report. Dr. Levine seconded the motion which carried.

Science Talent Search.—Dr. Yohe summarized the activities of this Committee and announced 4 Washington Trip Winners and 26 National Honorable Mentions in the Westinghouse Talent Search and 11 State Honorable Mentions which were selected by the Science Talent Search Committee.

Sustaining Memberships.—Dr. Kanatzar reported that the cooperation of the Illinois Chamber of Commerce was secured to aid in obtaining funds for the Junior Academy program.

State Museum Building.—Mr. Thompson announced that Senate Bill 656 was introduced and provided for a building to house the Illinois State Museum.

Reports of Special Committees

Resolutions.— Dr. Shaffer presented the report of the committee and the following four resolutions were adopted by the Academy.

1. *Appreciation to Host.*

   Whereas many persons connected with the Illinois Institute of Technology have been of great service to the Illinois State Academy of Science for the several ways in which they have made the necessary arrangements for the 52nd Annual Meeting,

   Be it resolved that the Academy express its gratitude to all who have participated in any way in arranging this annual meeting, particularly President J. T. Rettaliata, the Academy Vice-President in charge of local arrangements, Leslie R. Hedrick, and the heads of the various science departments who invited the Senior Academy to hold its annual meeting on the campus.

   Be it further resolved that the Secretary be authorized to send copies of this resolution to those specifically named and some additional copies for distribution by Mr. Hedrick to the science department heads and his various other helpers.

2. *Appreciation of Distinguished Service.*

   Whereas Gideon H. Boewe, of the Illinois State Natural History Survey, has served the Academy as member, chairman, and co-chairman of its membership committee for more than 15 years, and

   Whereas the membership of the Academy during this period has more than doubled largely because of his devoted efforts,

   Be it resolved that the Academy express its appreciation for his efforts which have meant so much to the continuation and strength of the Academy.

3. *Whereas* the Illinois Academy of Science has for many years urged each successive state administration to construct a proper building to house the Illinois State Museum, and

   Whereas Senator Hart of Streator, Senator Crisenberry of Murphysboro, Senator Gray of East St. Louis, and Senator Drach of Springfield, have this past week on April 21, 1959, introduced Senate Bill No. 656 for An Act to provide for the construction of a building to be used as the Illinois State Museum in Springfield they are to be commended and given every possible support for their efforts to secure passage of this bill.

   And *Whereas* on April 22, 1959, Governor William G. Stratton in his annual budget message to the State Legislature did state under Capital Outlay: "Included is a $2,646,000 recommendation for a building to house the Illinois State Museum. The valuable work of this outstanding institution has been seriously hampered in recent years, and the public greatly inconvenienced by cramped and inaccessible quarters. The space it now occupies can readily be converted to office use by other agencies." That he is to be commended and urged to push this project through with utmost dispatch.

   And Whereas the Secretary of State has publicly given his support to this much-needed expansion he too is to be commended for his stand.

   And Whereas Dr. Percival Robertson, Chairman of the Academy's Committee for a new Museum building, has worked diligently to arouse statewide interest in the need for a State Museum building we wish to commend him on the success of his efforts so far and to urge the entire membership of the Academy to

TREASURER'S REPORT

May 1, 1958-March 31, 1959

BALANCE, May 1, 1958		$ 6,160.73
RECEIPTS		
Annual Dues		
Regular	$ 2,927.36	
Sustaining—Patron	1,415.00	
Life	50.00	
Registration at Urbana	134.00	
Interest		
U. S. bonds	76.60	
Savings	140.00	
A.A.A.S. research grants	200.00	
	$ 4,942.96	
TOTAL, balance and receipts		$ 11,103.69
EXPENDITURES		
Council	$ 254.13	
Secretary's office	666.84	
Treasurer's office	208.51	
Editor's office	88.41	
Miscellaneous	37.50	
Research grants	200.00	
Membership committee	232.22	
Honoraria	350.00	
Librarian	432.74	
Junior Academy		
General	1,996.72	
Science talent search	420.59	
Sustaining membership committee	7.86	
Publications committee	1,257.80	
National Science Foundation	22.60	
TOTAL, expenditures		$ 6,175.92
CASH ON HAND	4,927.77	
Outstanding checks	250.00	
TOTAL, Carbondale National Bank, March 31, 1959		$ 5,177.77
BALANCE, National Science Foundation		$ 3,528.16
CURRENT FUNDS		$ 1,649.61
RESERVE FUND		
State Savings and Loan Assn., East St. Louis	$ 4,000.00	
U. S. Bonds	1,800.00	
		$ 5,800.00
PERMANENT FUND		
Life memberships		
U. S. Bonds	$ 1,700.00	
Cash in Carbondale National Bank	50.00	
		$ 1,750.00
FRANK H. REED MEMORIAL FUND		
State Savings and Loan Assn., East St. Louis	$ 408.19	
Interest to December 30, 1958	7.14	
		$ 415.33
TOTAL FUNDS		$ 7,965.33

support him by making known immediately to all their state legislators their support of Senate Bill No. 656 for a new Museum building. *Be it resolved* that the Secretary send a copy of this resolution to those specifically named.

4 *Necrology*

Whereas during the past year the Academy lost by death the following members:

Edward Bartow, July 10, 1958
Lester E. Bower, March 3, 1959
Jacob F. Cart, April 6, 1958
Francis A. Coolican, February 22, 1959
Robert Daley, August 21, 1958
Harold J. Eigenbrodt, November 28, 1958
Ovid W. Eshbach, May 26, 1958
Henry E. Ewing, 1958
Carl H. Gamble, 1958
Edward L. Hill, June 6, 1958
William J. Gerhard, December 31, 1958
Virginia H. Kline, February 5, 1959
Elmer R. Knight, 1958
Vida A. Latham, May 21, 1958
Arthur R. Schweitzer, June 12, 1957

Be it resolved, that the Academy express its grief for their passing by rising for a moment of silence.

Planning.—Dr. Levine explained the work of the Committee during the past year and also the need for the changes in the Constitution which were proposed for consideration at this annual meeting.

Film Editing.—Mr. Thompson announced that this group had previewed 64 films and approved 35 for use in classrooms. The list of recommended films will be published in the *Transactions*.

Nominating.—In the absence of Dr. Wantland, Dr. Yohe read the report of the Nominating Committee. President Mills called for further nominations from the floor. No other nominations were made and Dr. Ekblaw moved nominations be closed and the Secretary cast a unanimous ballot for those named in the report of the Nominating Committee. The motion, seconded by Miss Hunter carried.

As the Nominating Committee was unable to name a candidate for Chairman of the Junior Academy, Dr. Levine moved that the Council be empowered to fill this vacancy. The motion was seconded by Miss Hunter and carried.

New Business

Several amendments to the Constitution had been proposed and had been published in the Secretary's letter of March 18, 1959. President Mills asked the Secretary to read the sections as they appeared in the Constitution and Dr. Levine to read the proposed amendment.

Dr. Ekblaw moved that the changes in Article III. Section 2 be approved. Dr. O. B. Young seconded the motion which received the required three-fourths affirmative vote of those attending the meeting and thus carried. (The amended articles appear in this issue of the *Transactions*).

Dr. Levine moved that the changes in Article III, Section 3, be approved. Dr. Ekblaw seconded the motion. Mr. Jack Bennett moved to amend the proposed changes to provide for a $2.00 membership for undergraduate and graduate students. The motion, seconded by Mr. Austin, did not carry. President Mills called for a vote on the original motion but that did not receive the necessary three-fourths affirmative vote.

Dr. Ekblaw moved that the members be permitted to reconsider later in this meeting the proposed change in dues and that for consideration in the 1960 meeting an amendment to provide for a student membership at $2.00 a year be drafted by a committee. Dr. Frye seconded the motion which carried.

Dr. Ekblaw then moved we reconsider and accept the amendment to Article III, Section 3, as published. This motion, seconded by Dr. Hirsch, received the necessary three-fourths affirmative vote and carried.

The meeting was then recessed to permit the serving of the Annual Banquet. After the banquet, President Mills asked for the remaining amendments to the Constitution. Each was voted upon separately and all were approved.

The meeting adjourned at 7:15 p.m. upon a motion by Dr. L. J. Thomas, seconded by Dr. Schoffman.

ARTICLES OF THE CONSTITUTION AS AMENDED APRIL 24, 1959

Article III. Membership and Dues

2. Individual members in good standing shall have the privilege of voting at the annual meeting, holding office, offering papers for presentation at meetings, having such papers published if accepted by the Board of Editors and receiving one copy of the current *Transactions* of the Academy. No member in arrears shall receive the *Transactions* for any year for which he is or remains in arrears.

3. The dues shall be as follows:

Regular member, annual	$ 5.00
Life member, single payment..	$100.00
Sustaining member, annual.....	$10.00 - $49.00
Patron, annual...	$ 50.00 or more

5. The fiscal year of the Academy shall be from *January 1 through December 31.* Members who fail . . . .

Article V. Council

1. The council shall consist of the President, First Vice-President, Second Vice-President, Secretary, Treasurer, Librarian, General Chairman of the Junior Academy, Co-ordinator of the Collegiate Section, the immediate past President, the immediate past Secretary, and the immediate past Treasurer, each for a term of one year, and three Councilors-at-Large. These last shall be elected for three year terms, only one being elected each year, except that the first year this provision is put into effect one Councilor-at-Large shall be elected for a one-year term, one for a two-year term, and one for a three-year term.

Article VI. Technical Personnel

Section 1 was deleted.

Section 2, changed to become Section 1.

1. A Publicity Advisor.....

Article IX. Publications

1. The regular publication of the Academy shall be the *Transactions of the Illinois State Academy of Science.*

Section 3 was deleted.

Section 4 becomes Section 3.

Article X. Business and Finance

5. The Secretary and Editor shall each receive an honorarium in amounts to be determined by the Council. These honoraria shall be paid by the Treasurer annually in March.

PREPARATION OF MANUSCRIPTS FOR THE TRANSACTIONS

For publication in the *Transactions*, articles must present significant material that has not been published elsewhere. Review articles are excepted from this provision, as are brief quotations necessary to consider new material or varying concepts. All manuscripts must be typewritten, double spaced, with at least one-inch margins. The original copy, not the carbon copy, is to be submitted.

Titles should be brief and informative. The address or institutional connection of the author appears just below the author's name. Subtitles or center headings should be used; ordinarily one uses subtitles such as *Introduction*, *Acknowledgments*, *Materials*, *Methods*, *Results*, *Discussion*, *Summary*, and *Literature Cited*. All papers should have a summary.

No footnotes are to be used.

The section entitled *Literature Cited* must include all references mentioned in text. It is not to include any other titles. No references to the literature are to be placed in footnotes. Citations under *Literature Cited* are as shown below:

Doe, John H. 1951. The life cycle of a land snail. Conchol., 26(3): 21-32, 2 tables, 3 figs.

Doe, John H. 1951. Mineralogy of Lower Tertiary deposits. New York, McGraw-Hill Book Co., iv + 396 pp.

Quoted passages, titles, and citations must be checked and rechecked for accuracy. Citations to particular pages in text are Doe (1908:21-36) or (Doe, 1908:21-36); general citation in text is Doe (1908) or (Doe, 1908).

Tabular information should be kept at a minimum. Tables should not be more than one page in length. Do not duplicate tabular data in text. Headings for tables and columns should be brief. Reduce to the barest essentials, or preferably omit, explanatory notes on tables. Each table and its heading should be on a single page; do not place any table on the same page with text.

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Legends for photographs and figures should be brief; type them on a separate sheet of paper. Indicate figure number and your name on back of illustration; do not write with pencil on the backs of photographs.

Authors will receive galley proofs; these should be read carefully and checked against the original manuscript. Reprints may be ordered at the time galley proofs are returned to the Editor:

HARVEY I. FISHER,
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Southern Illinois University,
Carbondale, Illinois.

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1959

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MAR 30 1959

TRANSACTIONS of the ILLINOIS STATE ACADEMY of SCIENCE

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WILLIAM G. STRATTON, *Governor*

MARCH 15, 1960

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USE OF MAMMALIAN SKULLS AND MANDIBLES BY PREHISTORIC INDIANS OF ILLINOIS

PAUL W. PARMALEE
Illinois State Museum, Springfield

Prehistoric Indians that once occupied the eastern United States subsisted almost entirely upon game which inhabited areas where their camps and villages were located. Although certain wild plants provided some food, as well as cultivated crops grown by later cultural groups, the bulk of the diet of aboriginal Illinois Indians consisted of native mollusks, fishes, turtles, birds and mammals. Especially in the case of the latter two, many of the bones were worked and fashioned into a variety of ornaments, tools and utensils.

In most instances it appears that such bone artifacts represent a secondary use of the animal, the primary use having been as food. However, worked mandibles and maxillae of the black bear and gray wolf, for example, have been found in association with human burials, primarily those of the Hopewell culture, while their other remains are almost entirely wanting in village midden deposits and refuse pits. These often elaborately cut and drilled sections of maxillae and mandibles were of special significance—possibly religious, a symbol of bravery, or simply as an ornament or trophy.

This type of bone artifact has been found in association with all three major prehistoric cultural groups (Archaic; Woodland; Mississippian) in Illinois, but apparently only during the Hopewell phase of the Woodland Culture were there any "extensive" manufacture and use of these bone ornaments. The only thoroughly excavated Archaic site in the state is the Modoc Rock Shelter Site (Fowler, Winters, and Parmalee, 1956) located in southwestern Illinois. Although no extensively worked or drilled mandibles or maxillae were found, a right mandible of a bobcat was recovered that had apparently been cut at the symphysis (separating it from the left half) and handled or worn a great deal as evidenced by its smoothed and polished appearance.

Mayer-Oakes (1955: 209, Fig. 19-1) has illustrated a "Cut, polished and perforated bear jaw" from the Archaic East Steubenville Site in Ohio; generally, such bone artifacts are uncommon in Archaic sites. However, some unique artifacts have been reported from the Archaic Indian Knoll Site in Kentucky. A section of the skull (rostrum) and mandible of a bobcat were found with three burials, while two cut mandibles of the gray wolf and four mandibles (plus the rostrum) of the fisher, *Martes pennanti,* occurred with others (Webb, 1946: 228, Fig. 30). These are of special interest since they were associated with a preceramic culture. The use of cut mandibles and maxillae for decorative and/or ceremonial (?) purposes, primarily those of the larger carnivores and mustelids, apparently decreased with the decline of the Hopewell culture. They are

known from the later Mississippian groups, but are uncommon and do not exhibit the workmanship of the cut and perforated bones of the Hopewell period.

Canine teeth, mostly from smaller carnivores such as raccoon and fox, and typically perforated at the root end for suspension, have been found in varying numbers at several Illinois sites. Deuel (1952b) refers to 179 perforated canine teeth of the raccoon that "lay in the neck region of a skeleton of a middle-aged person in Baehr Mound 2 (Brown County)." He also noted more than 200 drilled incisors of squirrels, that occurred with a skeleton in the Hemphill Mound in Brown County. The incisors of beavers were often used as a tool, possibly some type of chisel; more have been found at the Fisher Site (Will County) than in any other Illinois site.

The following accounts deal with the species of mammals utilized by the prehistoric Indians of Illinois for the manufacture of jaw and skull ornaments, pendants and utensils. These data provide an index to cultural traits, to the use and possible significance of certain species to the Indian and to the former abundance and distribution of these animals. Figure 1 illustrates several typical cut mandibles and maxillae which have been recovered at various archaeological sites in Illinois.

Accounts of Species

BLACK BEAR, *Ursus americanus* Pallas.—Now extinct in Illinois, the black bear was fairly common in wooded sections in early times. As noted previously, remains are rare in refuse pits and midden debris of prehistoric sites in Illinois and apparently only historic tribes used the bear for food, and possibly for robes and clothing. To the prehistoric Indian (primarily Hopewell) the bear appears to have had special significance and apparently was killed principally for the canine teeth, mandibles and skull.

Illustrations and discussions in the literature dealing with the bear's canine tooth and its use as a pendant or necklace component are too numerous to list. These teeth were a favorite with the aborigines; some were split, often drilled (one to several holes) and occasionally inlaid with pearls. The manufacture of imitation bear's teeth by the Indian is especially noteworthy since it also infers that the bear had special significance. Such canine teeth, made from bone, occurred in the Wilson Site Cemetery (Wh°10), White County (Deuel, 1952a) while two similar shell "teeth", fashioned from the axis of a marine whelk, were found with a burial in the Morton Mound F°14 in Fulton County (Cole and Deuel, 1937); these carved shells had apparently been worn as ear pendants.

Several imitation bear's teeth made from sheet copper have been recovered in mounds of the Liverpool group in Fulton County. Five of these (Dickson Mounds State Park Museum near Lewistown) were found lying on the skull of a burial, apparently having been worn as a head band. Each was approximately three and one-half inches long and contained two, centrally drilled holes. Four imitation canines were found at the Weaver Site, Ful-

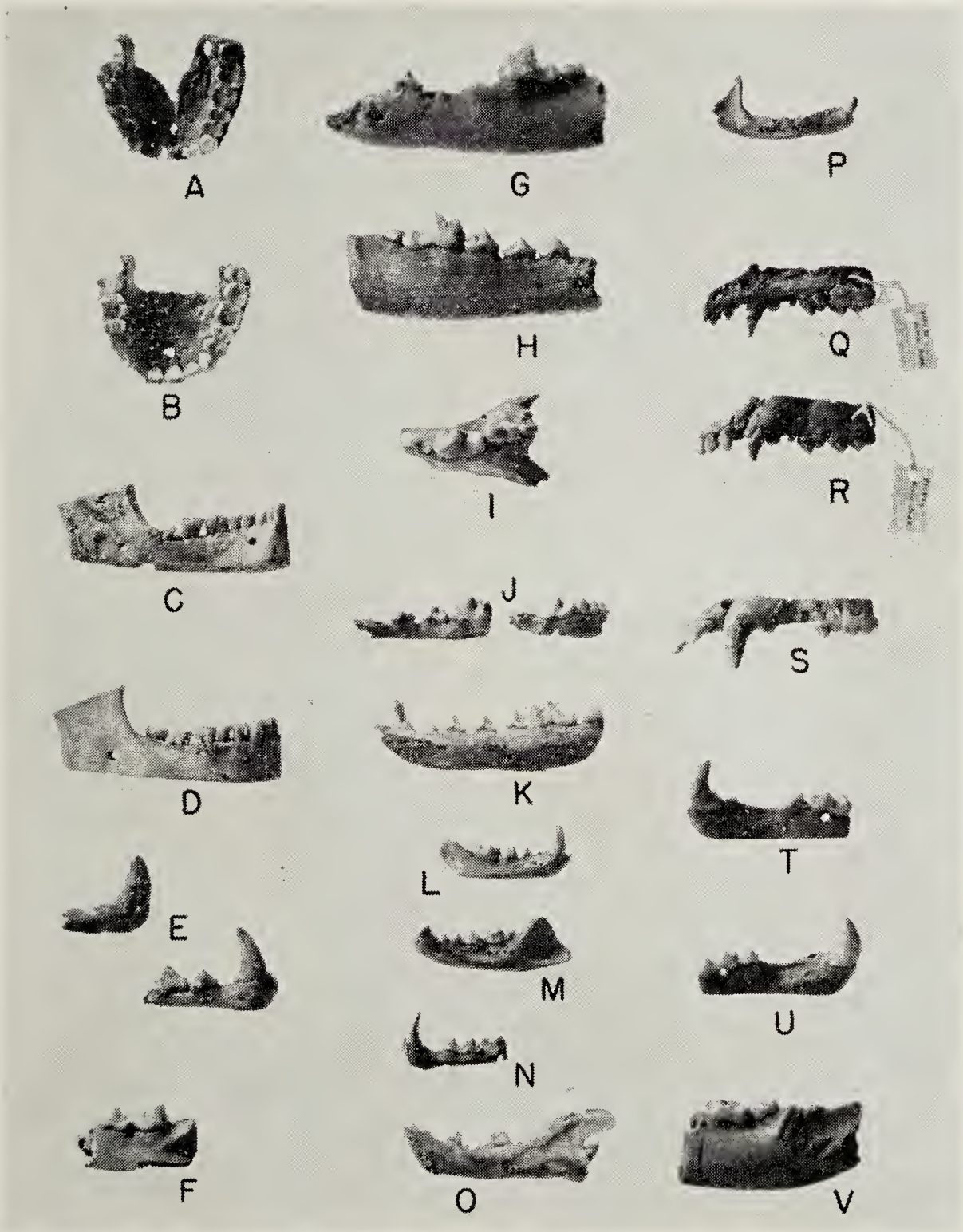

FIG. 1.—Types of cut mandibles and maxillae from archaeological sites in Illinois. *A* and *B*, palatine sections of human skull, Liverpool mounds, Fulton County; *C* and *D*, human mandibles, Sister Creeks Site, Fulton County; *E*, mountain lion mandibles, Mound F°191, Fulton County; *F*, mountain lion mandible, Little Chains Site, White County; *G* and *H*, mandibles of gray wolf and *I*, maxilla of gray wolf, Clear Lake Site, Tazewell County; *J*, maxillae of domestic dog, Clear Lake Site; *K*, coyote mandible, Cahokia Site, Madison County; *L* and *M*, badger mandibles, Clear Lake Site; *N*, bobcat mandible, Jersey County, Mound 69; *O*, bobcat mandible, Modoc Site, Randolph County; *P*, raccoon mandible, Snyders Site, Calhoun County; *Q* and *R*, black bear maxillae, Dickison Mounds, Peoria County; *S*, black bear maxilla, Mound Wh°6, White County; *T* and *U*, black bear mandibles, Liverpool mound; *V*, black bear mandible, Clear Lake Site.

ton County (Wray Coll., I.S.M.); two with a male human burial in a Hopewell cemetery and two in a house pit in the village. These ear pendants had been made by overlaying sheet copper on wood carved in the shape of a canine; portions of the wood were stilled preserved.

One of the most unique artifacts encountered thus far in Illinois was found in a "log tomb" mound (Hopewell) of the Liverpool group. A piece of bone had been cut and ground to resemble a handled dagger while the canine tooth of a bear had been hollowed out to serve as its sheath. A line drawing of this artifact (Dickson Mounds State Park Museum) is shown by Moorehead (1928: Pl. 49). Although he refers to it as that of a "grizzly bear tusk", it is probably the canine of a large black bear.

Cut and drilled maxillae and mandibles have been found in association with Hopewell burials in Illinois, maxillae being the more common. Bone artifacts fashioned from skulls generally included that portion obtained by cutting through the roots of the teeth and longitudinally through the palatine section; typically, each contained three incisors (premaxilla), the single canine, the premolars, and the first molar. Four such artifacts (two bears) from the Dickison Mounds in Peoria County are mistakenly illustrated as "halves of wolf mandible" (Deuel, 1952a.: Pl. 8, Figs. A and D). Three others occurred in the Wilson Mound Wh°6 and two in Mound Wh°7, White County (Deuel, 1952a: Pl. 67, Figs. D and G, and Pl. 72, Fig. C).

Two cut and drilled bear mandibles (same individual) were recovered with a human burial in a Liverpool mound (Dickson Mounds State Park Museum). They were cut similar to the skull types and, although the incisor teeth were missing, the original artifact apparently include the apex of the mandible. Evidently, the only other artifact made from a black bear jaw and found in Illinois was recovered at the Clear Lake Site, Tazewell County, (Schoenbeck coll., I.S.M.). The ascending ramus of a left mandible had been cut away and it had also been cut at right angles to its longitudinal axis, leaving only the second and third molars intact (Deuel, 1952a.: Pl. 50, Fig. O).

RACCOON, *Procyon lotor* (Linnaeus).—The quantity of raccoon remains found in numerous Illinois sites indicates extensive use of the raccoon by the Indian. Although certain bones (*e.g.* the ulna, radius and os penis) of the raccoon were modified and used as awls or other tools, the animal was probably collected primarily for its flesh and/or hide. Mr. Gregory Perino found a worked right mandible of a raccoon at the Snyders Site (Hopewell) in 1955 (I.S.M. coll.). The ventral side was ground flat and then several shallow grooves were cut in this surface at right angles to its longitudinal axis.

The only other Illinois record of a worked raccoon mandible is one described and illustrated by Maxwell (1951: Pl. 5) from the Sugar Camp Hill Site, Williamson County. He decribes it as "cut through the ramus, polished and scratched deeply with a knife along the labial wall". However, this description

does not fit his illustration and, according to Maxwell (pers. comm.), this was the preliminary field description of a specimen later classified as unworked. Maxwell (*op cit.*: 106) also states that "a lynx mandible was cut in back of the canine and gouged with three wide shallow incisions on the labial side at right angles to the longitudinal axis of the mandibles and drilled into, but not through the bone in two places on the lingual side"; this description applies rather to the illustrated raccoon jaw.

WOLVERINE, *Gulo luscus* (Linnaeus).—The presence of two cut and perforated sections of mandibles of this species in Mound No. 6 of the Havana Mound Group (Mason County) represents a unique record since there are no historic accounts of the wolverine in Illinois. These artifacts were described and figured as parts of a dog's jaw (Baker, 1941: 11, 69 and Pl. 7) but were later determined as *G. luscus* by Hoffmeister (1954) who states "Indians in Illinois probably obtained these bone artifacts only by trading with Indians far to the north or by hunting far to the north of the present boundaries of Illinois."

RIVER OTTER, *Lutra canadensis* (Schreber).—This mustelid was not uncommon in Illinois in early times but the limited number of otter bones at most sites indicates it was taken only occasionally by the Indian. There are apparently only three instances in which otter remains were used for ornaments or decoration. Mr. Perino recovered the cut palatine section of an otter skull in a Hopewell mound (No. 4 near Bedford, Pike County); this skull section contained the full complement of teeth. Langford (1927: Pl. 21, Fig. F) records a nearly complete skull and left mandible from the Fisher Site; it was described in his original notes as having been found "on a woman's forehead in the Middle Level of the Big East Mound EM". Originally the skull may have been worn (with the hide?) in the form of a headdress.

Mr. Theodore Shapas, Dolton, found the anterior half of a skull and the complete right dentary of *L. canadensis* with a human burial at the Anker Site, an Upper Mississippi Site at South Holland, Cook County. This find was noteworthy since the skull had been wrapped in sheet copper and copper disks had been placed in the eye sockets.

BADGER, *Taxidea taxus* (Schreber).—The badger is uncommon in Illinois although earlier it was reported as numerous, at least in the northern third of the state. Its bones have been identified from only five Illinois sites and, except for the complete skeleton (apparently interred by the Indians) found in Rose Mound No. 13, Schuyler County (Baker, 1941), they were few in number at each site. Three mandibles, a maxilla section and the anterior half of the skull were recovered at the Clear Lake Site (Schoenbeck coll., I.S.M.); two of the mandibles had been worked. The ascending ramus of one had been cut off at the mandibular foramen, but the other had been more elaborately worked (Deuel, 1952a: Pl. 51, Fig. I) with both the ventral side and most of the ascending ramus cut off and noticeable scratch marks on both lateral surfaces. It appeared polished, pos-

sibly from being handled; neither mandible had been perforated.

GRAY FOX, *Urocyon cinereoargenteus* (Schreber).—The only record of a fox mandible worked by the Indian occurred at the Pool Site, Pike County. Found in 1950 (Univ. Ill., Dept. Sociol. and Anthrop. coll.), the section of a right mandible had been worked to a limited extent; the ventral margin was ground to a flattened surface and the condyloid process was cut off. None of the teeth remained and it had been broken off between the carnassial and second molar. Possibly this slightly altered jaw was in the initial stages of manufacture and originally it probably included more of the mandible.

DOMESTIC DOG, *Canis familiaris* Linnaeus.—Remains of the domestic dog have been found in midden deposits of all cultural groups, from the Archaic to those of historic tribes. Bones of the dog were seldom modified for tools or ornaments by the Indian, although there are records from a few Illinois sites of cut limb bones of *Canis* and of ulnae fashioned into awls. The only skull or mandible artifacts that are probably referable to the domestic dog were recovered at the Clear Lake and Cahokia sites. At the former site, two sections of the right maxilla were found in the village debris. Although the anterior portions of both had been broken off and lost, it was evident that one had been cut off immediately posterior to the carnassial tooth while the other had been cut behind the last molar. The artifacts were not drilled and their use is a matter of speculation.

Mr. Perino found a section of a worked canid mandible in Mound No. 34 at the Cahokia Site, Madison County. The ascending ramus was cut off immediately behind the third molar and the ventral edge was ground down close to the base of the teeth; the mandible was broken where the carnassial tooth was originally located. Specific identification is uncertain since only the second molar remained, but this tooth and jaw section compares most closely with *C. familiaris*.

COYOTE, *Canis latrans* Say.— As evidenced by the scarcity of remains of this animal in Illinois sites, the coyote was rarely taken by the Indian. Two badly decomposed cut mandibles were found at the Kraske Site, St. Clair County, in 1957 by Mr. Perino and are probably *C. latrans*. He also recovered a section of a right mandible of the coyote at the Cahokia Site in 1956. This artifact bears scratch marks on both lateral surfaces and the proximal end had been cut off between the second and third molars and rounded along the ventral margin. It is noteworthy because this carefully worked jaw was recovered at a Middle Mississippi site.

McGregor (1958) reports a cut canid mandible with a burial at the Pool Site, Pike County. The ventral edge was cut off parallel to the long axis of the jaw and the posterior section had been removed by cutting through the mandible at the position of the carnassial tooth, leaving only the anterior one-third of the tooth. The anterior portion of the artifact originally included more of the mandible; it had been drilled just below premolars two and four. Specific determination

was difficult, but based on cusp structure, tooth dimensions and the general narrowness of the jaw, it compared most closely with coyote rather than dog or wolf as proposed by McGregor (1958: 139, 141, Fig. 46,f).

GRAY WOLF, *Canis lupus* (Linnaeus).—This large carnivore was reported to have been fairly common in the wooded sections of Illinois prior to 1800, but it has long been extinct in this region. Bones of the gray wolf have been reported from only nine Illinois sites and it was evidently seldom killed by the Indian. Artifacts fashioned from the bones of this species suggest it may have been sought more as a trophy animal than as a source of food. An ulna, apparently used as an awl, and the cut distal end of a humerus occurred at the Weaver Site, Fulton County (Wray coll., I.S.M.).

Two cut mandibles and a section of maxilla, probably the same individual, were recovered at the Clear Lake Site (Schoenbeck coll., I.S.M.). None of the artifacts were perforated; each had been cut through at the point of the canine tooth and the ascending ramus cut off, but all of the premolar and molar teeth were left intact. Another section of maxilla, probably of *C. lupus,* was also recovered at the Clear Lake Site (Wray coll., I.S.M.). Posteriorly, it had been cut through the middle of premolar three and, although only this and premolar two remained, the artifact originally was more extensive.

The maxillae of a wolf were recovered in 1956 by Mr. Perino at the Cahokia Site; although weathered and broken, these pieces bore evidence of having been cut. Maxwell (1951: Pl. 5) illustrates the worked jaws of this species recovered at the Sugar Camp Hill Site, Williamson County, and states "Also in Zone II were two sections of the right and left sides of a wolf mandible, flattened on the bottom, cut in back of the carnassial and perforated in six places". Langford (1927) refers to "two carved bear jaws" he recovered at the Fisher Site, although judging from the plates (17, e; 20), these (premaxillae-maxillae) appear to be a large canid, possibly wolf. Langford (*op cit.*: Pl. 17, d) illustrates and mentions a "part jaw (of canid?) showing chopping marks" that may also be *C. lupus.*

The cut right mandible of *C. lupus* was found at the Busch Estate Site (Woodland), Pike County (Univ. Ill. Dept. Sociol. and Anthrop. coll.). The unperforated mandible contained the third and fourth premolars and the anterior portion of the carnassial; it was cut off anteriorly at the second premolar and the ventral edge had been cut off parallel to the long axis of the jaw.

In 1957, Mr. Theodore Shapas, Dolton, recovered portions of two left mandibles of the gray wolf with a human burial at the Anker Site, Cook County. One mandible contained premolar four, the carnassial tooth and molar two, while all three molars and premolars two and three were still present in the other. These mandibles had been broken but were not cut or drilled, although they definitely had been part of the burial complex. On October 18, 1958, at the same Upper Mississippi site, Mr. Shapas found a cache of jaw

and skull remains above the pelvis of a burial; these may have been contained in a pouch of some sort. Except for the missing rami and the purposely (?) broken ventral margins, the lower mandible of this large wolf was complete. Also included was a single canine, the right premaxilla containing three incisors and canine tooth and both right and left maxilla sections, each with premolars three and four and both molars intact (probably all from the same wolf). Portions of the right maxilla and both mandibles of a bobcat formed part of the cache; these remains were not worked.

At this same site, Mr. David Pedric, Dolton, found two larger, nearly complete mandibles of *C. lupus* with a burial. The ascending rami were broken off and each, which still contained a full complement of teeth, had been drilled in two places at mid-point between the gum line and ventral edge, one below the third premolar and one below the carnassial.

There are apparently only two instances known in Illinois in which the skull of *C. lupus* was elaborately modified to form an artifact. A field party from the Department of Anthropology, University of Michigan, Ann Arbor, recovered a broken section of the right premaxilla-maxilla (Cat. No. 9829) of a wolf at the Snyders Site (Hopewell), Calhoun County, in 1947. It was broken behind the first premolar; only the three incisors and broken portions of the canine tooth and first premolar remained. The palatine section and upper part of the maxillary had been cut away and a hole drilled between the canine tooth and the third incisor; originally the complete artifact probably contained another drilled hole, posteriorly.

During the excavation of a burial in Mound 2 several years ago, at the Knight Site (Hopewell), Calhoun County, two unperforated premaxilla-maxilla sections of the gray wolf were recovered by Dr. P. F. Titterington, St. Louis (U. Mich. Cat. No. 44779). They were cut off immediately posterior to the second premolar and the maxillary had been cut away parallel to the gum line, exposing the roots of the teeth. All the incisors, canines and first and second premolars were intact.

MOUNTAIN LION, *Felis concolor* Linnaeus.—The comparatively few animals that once inhabited this region, coupled with the probable difficulty encountered by the Indian in killing the mountain lion, may account for the scarcity of its remains at sites. An unworked section of the pelvis occurred at the Starved Rock Site (LaSalle County), and the distal end of a tibia of this species was recovered in the village debris at the Rosiclare Site, Hardin County (I.S.M. coll.). An awl made from the ulna of this cat was found with a human burial by Mr. David Pedric at the Anker Site.

In Mound F°191 (Mitchell Mound), Fulton County, the cut anterior section of a right mandible that contained the canine tooth and both premolars was found by Dr. Don Dickson and mistakenly referred to in Cole and Deuel (1937) as "a wolf jaw". The fragment of a left mandible containing only the canine tooth (probably the same animal) was also recovered. Two cut and perforated mandibles of the

mountain lion (same animal, originally with the full complement of teeth) were found with a Hopewell burial in Mound Wh°7, White County, and are illustrated (Deuel, 1952a: Pl. 72, Fig. E) but mistakenly identified as "cut wolf jaws . . . ." The only other record is a broken section of left mandible (containing the molar tooth and premolar two) found by the author in July, 1956, at the Little Chains Site, White County. The ascending ramus had been cut off just posterior to the molar tooth.

BOBCAT, *Lynx rufus* (Schreber).—With reference to historic tribes in southeastern United States, Swanton (1946) mentions that "The wildcat seems to have been eaten at times and its skin was also worn". Faunal remains indicate that this cat was used to some extent by the aborigines, although artifacts fashioned from the bones of *L. rufus* are uncommon in Illinois sites. Titterington (1942) lists the "cut section of fox mandible, Burial No. 49—Mound 69", from the bluff focus in Jersey County, but this mandible is that of a bobcat. The right mandible of *L. rufus* recovered at the Modoc Rock Shelter (mentioned earlier in this paper) is the only artifact of its type known from an Archaic site in Illinois. The complete dentary and anterior two-thirds of a skull of a large bobcat were found on the chest of a human burial by Mr. Pedric at the Anker Site. Like the otter skull recovered at this site, the skull of *L. rufus* had been wrapped in copper and copper disks inserted in the eye sockets.

WHITETAIL DEER, *Odocoileus virginianus* (Zimmermann).—An almost limitless variety of artifacts fashioned from nearly all of the different bones of this animal have been found, but ornaments and pendants made from the skull or mandible are rare. However, there are records (*e. g.* Perino, 1957: Fig. 49) of complete mandibles which were used probably as some sort of grubbing or cultivating tool.

Four cut mandibles have been recovered from Illinois sites thus far. Maxwell (1951: Pl. 5) records a "cut and polished section of deer mandible" from the Sugar Camp Hill Site. A cut portion of the right mandible occurred with a burial at the Irving Site (late Middle Woodland), Pike County (McGregor, 1958: 150, Fig. 51 B). The ventral edge had been cut off parallel to the long axis of the jaw; the ascending ramus was removed by making a cut that began part way up on the anterior edge of the ramus and curved down to join the ventral cut. The artifact was broken and only the second and third molars remained; originally it probably included more of the dentary. The broken, worked section of a right deer mandible occurred at the Pool Site (Hopewell), Pike County (Univ. Ill., Dept. Sociol. and Anthrop. coll.). Again, the ventral edge was cut away and the anterior section had been removed by cutting immediately in front of the first premolar. Only broken portions of premolars one and two remained, although originally the artifact included the third premolar and at least the first molar.

A broken section of a left mandible was recovered by Mr. Raymond Bieri, Belleville, in a refuse pit at a Late Woodland site near Falling

Springs, Madison County. The ventral edge had been cut away and both lateral surfaces bore distinct scratch marks; although this artifact had originally included more of the mandible, only premolar three and the first molar remained. Deuel (1952b) states that "One of the most interesting finds from the Liverpool group (Mound 77?) consists of two antlers of a young Virginia buck found near the head of a skeleton and doubtless part of a headdress". This is apparently the only case noted from Illinois of complete deer antlers being used in this type of an ornamental or a decorative capacity.

MAN, *Homo sapiens* Linnaeus.—The use of human skulls and mandibles as ornaments and pendants appears to have been restricted in Illinois to the Hopewellian culture, and nearly all such artifacts have been found with human burials in Fulton County mounds (Sister Creeks and Liverpool sites). Typically, the mandibles were separated at the symphysis, the ventral surface was cut away along an even line, the ascending ramus was cut off half way to the coronoid process and each was perforated for suspension. The palatine section was kept (with the full complement of teeth) and, like the mandibles, was also drilled for suspension. Several of these human bone artifacts in the archaeological collections of the Illinois State Museum are illustrated (Cole and Deuel, 1937: Pl. 23, Fig A; Pl. 26, Fig. B; Pl. 31, Fig. B); similar specimens from Hopewellian mounds are on exhibit at the Dickson Mounds State Park.

Interesting hypotheses have been proposed by Deuel (1952b). "Since bear and wolf jaws were worn, it would seem that the more powerful fighting wild animals were chosen and hence, that the human mandibles and maxillaries were those of brave enemies and worn for a like reason. However, if the jaws had a protective quality or religious significance, they might rather represent friendly relationships and hence the human jaws might be those of dead friends, patrons or relatives."

Summary

Worked mandibles and/or maxillae of 13 species of mammals have been recovered from archaeological sites in Illinois. Although these bone artifacts occurred in Archaic and Mississippian sites, they have been encountered most frequently in Hopewell burial mounds. With respect to this latter cultural group, the mandibles and skull sections are more meticulously cut and polished and, in nearly every instance, perforated for suspension. The scarcity of bones of the black bear in the village midden debris of prehistoric sites in Illinois indicates that the animal was killed primarily for its skull, mandibles and canine teeth.

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um's collection as well as the loan of others. Dr. Elaine Bluhm, Department of Sociology and Anthropology, University of Illinois, Urbana, and Dr. Don. F. and Marion Dickson, Dickson Mounds State Park, Lewistown, were also most helpful in permitting the author to borrow specimens.

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ARTIFICIAL GROUND WATER RECHARGE AT PEORIA, ILLINOIS

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In Peoria, Illinois, ground water is obtained from glacial drift deposits varying from 10 to 200 feet in depth. In addition to municipal use, most industries also pump this water. In 1940 it was found by the State Water Survey that ground-water levels were dropping about two feet per year and that the cause was over-pumpage. It was also found that the river does not contribute to the ground-water storage when it is at pool level and only very little when in flood stages.

To reduce lowering of ground-water levels, two principles can be used: a) pump less water; or b) increase the recharge of ground-water storage. Both methods have been used. Once informed about the causes of the lowering, industry cooperated by reducing its pumpage to the extent of 15 million gallons per day mainly by using river water for condensers or by building cooling towers. These measures reduced the recession of water tables to about 0.6 foot per year.

A trial of artificial recharge was made in 1941 in an old gravel pit on the property of Hiram Walker & Sons, and it was found that recharge could be made at a rate corresponding to the height of a water column of 111 feet per day over the water surface or at rate of 37 million gallons per day per acre.

Artificial recharge can be obtained in several ways. In Peoria we studied the use of land flooding, pits, and wells.

Land-flooding, as a rule, gives rates of inflow from a few inches to a maximum of five feet. Inasmuch as in Peoria the over-pumpage was calculated to be 8 to 10 million gallons per day we would need 30 acres to flood if the rate of inflow averaged one foot per day. This amount of free land was not available in the industrial area where the recharge was needed.

It was, therefore, considered necessary to find a method which allowed a high rate of recharge over a small area. Wells or pits can be used for this purpose. Wells require clean water or they clog and are difficult to put back in operation. The cost of a filter plant and recharge wells was estimated to be about $5 million whereas the cost of a pit was approximately $100,000. From this standpoint it was not difficult to choose.

The quality of the river water was found to be satisfactory for infiltration; it had a turbidity of less than 100 p.p.m. for 300 days per year and a normal bacterial count of 26,000 per ml. However, convincing people locally that river water can be used for recharge required much time and effort.

The State of Illinois appropriated funds that would have allowed the construction of a small recharge test-pit with a capacity of about

300,000 gallons per day. The Peoria industries, being interested in getting even more water into the ground, raised an additional $70,000 to enable construction of a larger pit having a possible capacity of one million gallons per day over the year, that is, two million gallons per day over the approximate six-month operating period. The pit is operated only during the winter period when the river water is below 65°F. The contribution from the industries, fortunately, was made with a free rein for research, and there was never any pressure exercised merely to get more water into the ground. The water committee of the Peoria Association of Commerce always considered the work as a research project designed and operated to find ways to solve the problem of rapid recharge.

Description

The installation is relatively simple. River water passes through a coarse screen to a so-called control tower, where it is chlorinated, measured, and passed through fine screens with ⅛-inch slots. It then enters the pit which has its bottom 10 feet below pool stage of the river and thus is charged by gravity flow. To protect the natural ground from settling the pit was lined with a six-inch layer of filtering material.

In 1956 a second recharge pit, with some modifications in shape, was built near the first one. The water is pumped into this no. 2 pit.

Whereas pit 1 has a bottom 40 by 62.5 feet (2500 sq. ft.) with 1:2 slopes, pit no. 2 has a bottom of 20 by 75 feet (1500 sq. ft.) with 1:3 slopes.

Industrial Pits

The pit belonging to the Bemis Brothers Bag Company in Peoria, which has a bottom only 10 by 50 feet and slopes of 1:3, was built with advice of the Water Survey.

In contrast the Peoria Water Works Company built a pit with a bottom 350 by 200 feet and 1:3 slopes with a six-inch layer of sand as filter.

There are in Peoria, therefore, four pits of various shapes available for observation and comparative study.

Rates of Inflow

It is interesting to compare the average rates of inflow in feet per day in these pits.

Pit 1	60
Pit 2	120
Bemis Bag Co. pit	200
Water Works Co. pit	8

The Peoria Water Works Company pit approaches land-flooding types of recharge in size and recharge rate.

The high recharge rate of the other pits, however, is surpising and exceeds the rate of any known pit. The reasons for this high rate are well worth discussing, as the design of many pits seems to overlook some fundamental reasoning.

Design Factors

In any recharge pit, the water level in the pit must be above the original ground-water level in order to have some head to produce flow. The volume of soil between the pit and the ground water is soon saturated with water. In Peoria we calculate that this happens in three hours.

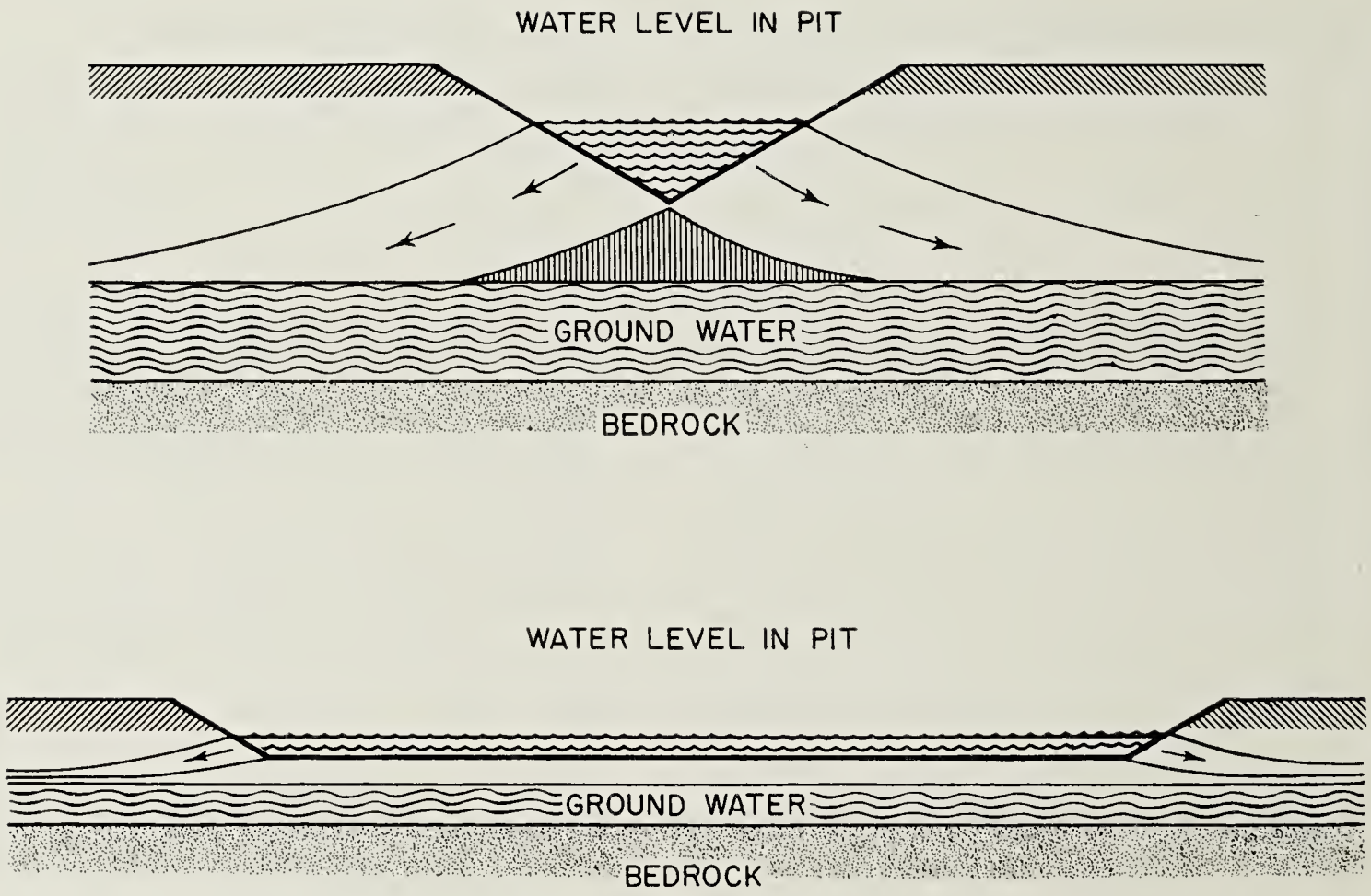

FIG. 1.—Sections through pits and flow diagram; *above*, Pit without bottom, only slopes; *below*, Pit with large bottom.

Any additional water can flow from the pit only if it can flow from the pit laterally. The water flowing through the sides of the pit has a free direct path for this lateral flow. The water flowing through the bottom has to squeeze through underneath the flow from the sides, and in large bottoms the flow from one part of the bottom can block or hold back flow from another part. It thus becomes evident that large bottoms are of no great help in increasing the rate of inflow.

Assuming a pit without a bottom (Fig. 1, above), there is flow only through the sides, and beneath its lowest point is a sector with no flow, as stream lines cannot cross themself.

In a pit with a very large bottom (Fig. 1, below), it can be seen that a limited lateral flow is possible only through a section along the edge of the bottom due to its permeability. This accounts for the low rate of inflow in land-flooding operations.

The geometrical shape of the pit is therefore of great importance in obtaining a high rate of inflow.

It was also found that a high percentage of the wet area should be in the slopes (Fig. 2). At operating levels in the pits in Peoria, this area amounts to:

Pit 1	55 percent
Pit 2	75
Bemis Bag Co.	90
Water Works Co.	20

FILTER MATERIAL

Another rather unexpected factor in obtaining and maintaining high rates of infiltration was the filter material.

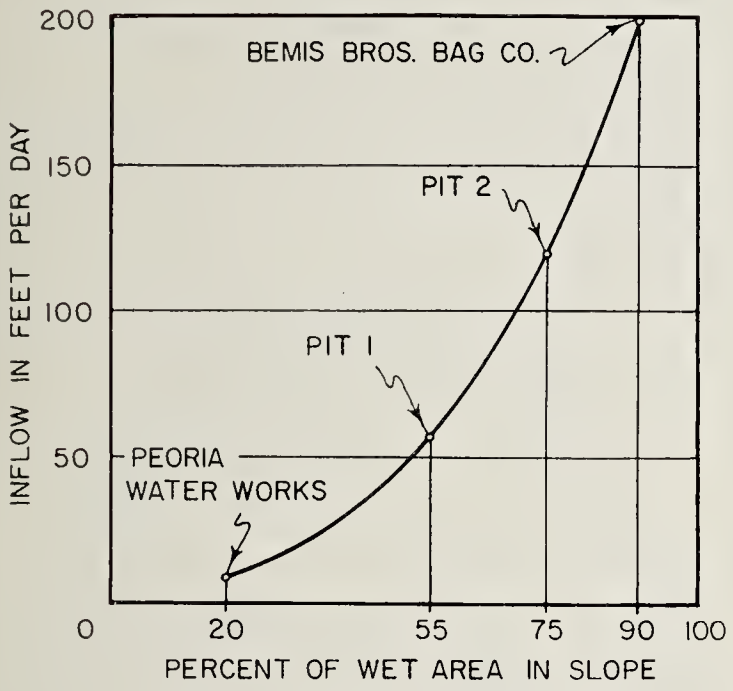

FIG. 2.—Relation between inflow and percent of wet area in slope.

For the first three years sand of one-millimeter size was used for filtering. This sand clogged rapidly and at the end of a winter season the capacity of the pit was reduced 40 to 60%. Then, in a bold step, 3/8-inch gravel was used as filter material. This material was predicted as not being capable of acting as a filter, but in our testing it proved effective.

A silt film developed rapidly over the gravel and the top gravel collected more silt than the lower layers. At the end of the season practically all of the silt introduced into the pit by the river water could be accounted for in the top layer of gravel. What was even more important, the initial inflow was about 5% higher than with sand as a filter and the reduction during a winter season amounted to only 12 to 15%. This solved to a great extent the constancy of the pit operation.

During 1957-58 pits nos. 1 and 2 were operated without previous cleaning. So far the loss in the recharge rate is only 4% compared to the previous year. This low loss of capacity suggests that operation of the pits may be possible three years without cleaning.

It is our opinion that use of pea gravel as a filtering material, geometric shape of the pit, and flow through the sides are the main factors in the high rate of recharge of the pits in Peoria. However, many other factors also enter the problem of ground-water recharge.

CONCLUSIONS

Technically, we found a way to produce a high rate of recharge of water into the earth. On the other hand we do not yet know why many of the methods work. We do not know the most favorable geometric shape for a pit or the proportions of sides, bottom, and slopes. We do not know why pea gravel actually filters or the limit of coarseness of material that could be used. However, theoretical and experimental studies on these explanations are underway.

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EIMERIA (PROTOZOA: EIMERIIDAE) FROM THE RICE RAT AND PYGMY MOUSE IN MEXICO

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Materials and Methods

During the summer of 1958 a collecting expedition to Mexico was made by Dr. David L. Langebartel and John R. Winkelmann of the Department of Zoology, University of Illinois. They collected fecal specimens from 13 bats and 6 rodents, placed them in 2.5% potassium bichromate solution, and brought them to Urbana for examination.

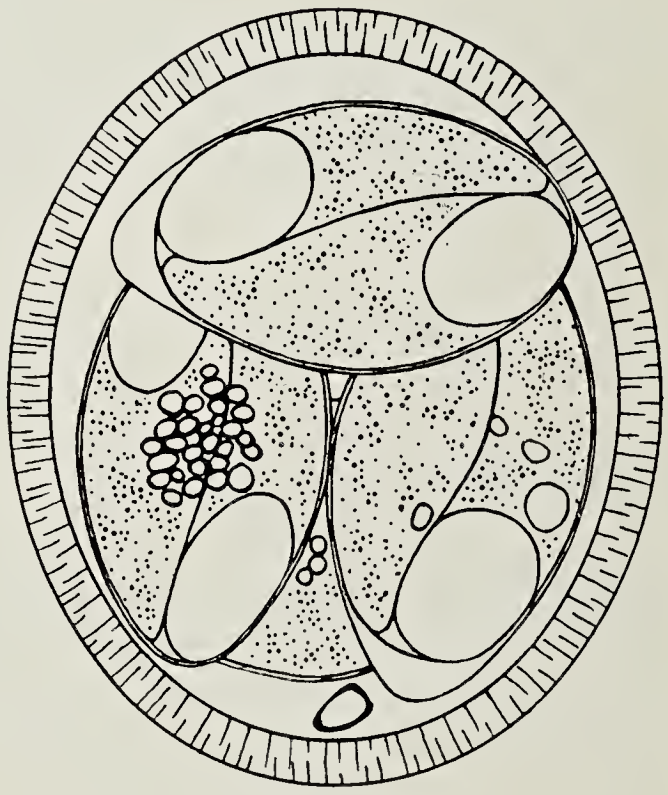
Each sample was mixed thoroughly, placed in a thin layer in a Petri dish at room temperature for a week to sporulate, and stored in a refrigerator. The samples were examined after sugar flotation, using a Leitz Ortholux microscope with apochromatic objectives.

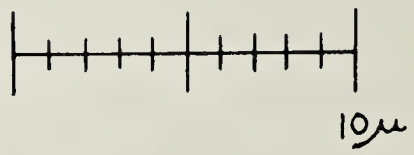
No coccidia were found in the bats, but one new species and one previously described species of *Eimeria* were found in the rodents.

The skins and skulls of the host animals are preserved in the University of Illinois Natural History Museum. The numbers given with the host designations are those of the host animals in the museum.

Acknowledgments

We should like to express our appreciation to Dr. Langebartel and Mr. Winkelmann for providing the specimens and to Dr. Donald F. Hoffmeister, Director of the Museum, for making final identifications of the hosts.





Results

Eimeria couesii n. sp.

Diagnois: *Eimeria*: Oocysts (Fig. 1) ellipsoidal, pale yellowish. Five sporulated oocysts were 20-23 by 17-20 microns with mean of 21.4 by 18.0 microns; length-width ratio was 1.20; wall somewhat rough and pitted, heavy, composed of single layer about 1.3 microns thick, with radial striations. Micropyle absent. Oocyst residuum absent. Oocyst polar granule present. Sporocysts ovoid; seven measured 10-14 by 7-8 microns with mean of 11.7 by 7.7 microns; length-

width ratios ranged from 1.2 to 1.8, mean of 1.53. Stieda body present. Sporozoites oriented longitudinally in sporocysts, with large clear yellowish globule at large end. Sporocyst residuum composed of rather loose granules or absent.

Host: Rice rat, *Oryzomys couesi couesi* (No. 18,833)

Location: Feces.

Locality: Oaxaca, Mexico.

The oocysts of *E. couesii* have been compared with the descriptions of all the other species of *Eimeria* reported from rodents. They differ from them all. However, since it has not been possible in any cross transmission experiments to infect rodents of one genus with *Eimeria* species from rodents of another genus, it is not considered necessary here to differentiate *E. couesii* formally from species of *Eimeria* other than those which have been reported from rodents of the genus *Oryzomys*. The only one of these is *E. oryzomysi* Carini, 1937 from *Oryzomys* sp. *E. couesii* differs from *E. oryzomysi* in having a polar granule, in lacking an oocyst residuum, and in heavy, striated rough oocyst wall rather than a smooth, thin one.

Eimeria baiomysis Levine, Ivens and Kruidenier, 1958

This species was found in a pygmy mouse, *Baiomys musculus* (No. 18,832), collected at Oaxaca, Mexico. Only three sporulated oocysts were seen. They measured 23-24 by 20-21 microns.

E. baiomysis was originally described from *Baiomys taylori* from Queretero, Queretero, Mexico. The present report is a new host species record.

Summary

Eimeria couesii n. sp. is described from the rice rat, *Oryzomys c. couesi* from Oaxaca, Mexico. Its oocysts measure 20 to 23 by 17 to 20 microns. *E. baiomysis* Levine, Ivens and Kruidenier, 1958 is reported from the pygmy mouse, *Baiomys musculus*, from the same locality, a new host record.

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TWO APPLICATIONS OF ELEMENTARY NUMBER THEORY

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Introduction

This note is concerned with two applications of elementary number theory to numerical quantification theory. The first application deals with a numerical aspect of symbolic logic and the second application is directed toward determining a "shortcut" procedure for indicating when a certain class of integers divides another class of integers. The results are given in terms of some general theorems and some specific examples.

Symbolic Logic

For compactness of notation, frequently one represents a sequence of binary digits as a decimal integer with fewer digits (Caldwell, 1958, and Mullin, 1958). However, such a procedure is accompanied by the apparent difficulty of quickly regenerating from the decimal integer either some or all of the binary digits. Hence one is motivated to consider operations involving only the decimal integers to retrieve some or all of the binary digits (Mullin, 1958, and Abrahams, 1955). A method to effect this wish is given in the corollary of the following:

Theorem 1.1: Put $d = \sum_{i=0}^{n} a_i B^i$, where B is some integer greater than *1*, each a_i $(i=0,1,...,n)$ is an integer satisfying the condition $0 \leq a_i < B$ and n is a non-negative integer. Put $P_k = [\frac{d}{B^k}]$, where if a is real, $[a]$ is the greatest integer not exceeding a. Then $P_k \equiv a_k \pmod{B}$, $(k = 0, 1, .., n)$.

Proof: $\frac{d}{B^k} = \sum_{i=1}^{n-k} a_{i+k} B^i + a_k + \sum_{i=1}^{k} a_{k-i} B^{-i}$.

Put $f_k = \sum_{i=1}^{k} a_{k-i} B^{-i}$. Since $max\ a_j = B-1$, then

$$0 \leq f_k < (B-1) \sum_{i=1}^{\infty} B^{-i} = 1.$$

Putting $S_k = \sum_{i=1}^{n-k} a_{i+k} B^i$, notice that there exists an integer I_k such that $S_k = B \cdot I_k$.

Hence $P_k = S_k + a_k = B \cdot I_k + a_k$.

Therefore, $P_k \equiv a_k \pmod{B}$.

Definition 1.1: The decimal integer d is said to contain 2^k in its binary number representation if and only if $a_k = 1$ $(k = 0, 1, ..., n)$ in $d = \sum_{i=0}^{n} a_i 2^i$.

Corollary 1.1: The decimal integer d contains 2^k in its binary number representation if and only if $[d \cdot 2^{-k}]$ is odd.

Proof: Put $B = 2$ in Theorem 1.1.

Example 1.1: Does 94 contain 2^2 in its binary number representation?

Consider,

$$[\frac{94}{4}] = [23\ 1/2] = 23, \text{ odd.}$$

Therefore, 94 does contain 2^2 in its binary number representation. In fact 94 is a brief representation for *1 0 1 1 1 1 0*, where the *1* in the third position from the right indicates the presence of $1 \cdot 2^2$.

$C^n \mid A;\ A, C, n$ integers

A certain class of problems have the *a priori* condition that only those

integers which satisfy any other conditions of the problem are to be called solutions. This is the case with Diophantine analysis (Landau, 1958). The following results are useful, in some instances, for the purpose of giving a quick check to determine whether the *a priori* necessary condition is satisfied.

Theorem 2.1: Put $d = \sum_{i=0}^{m} a_i B^i$, where B is some integer greater than 1, each a_i $(i = 0, 1, ..., m)$ is an integer satisfying the condition $0 \leq a_i < B$ and m is a non-negative integer. Put $d^* = \sum_{i=0}^{n-1} a_i B^i$, where n is an integer satisfying the condition, $0 \leq n \leq m$. Put $\bar{d} = \sum_{i=n}^{m} a_i B^i$. If, and only if,

(i) there exists an r_1 such that $0 \leq r_1 < C^n$ and $d^* \equiv r_1 \pmod{C^n}$

and (ii) there exists an r_2 such that $0 \leq r_2 < C^n$ and $\bar{d} \equiv r_2 \pmod{C^n}$, implies either

(iii) $r_1 + r_2 = 0$ *or* $r_1 + r_2 = C^n$ then $C^n \mid d$.

Proof:

(1) $d^* = I_1 C^n + r_1$, where $0 \leq r_1 < C^n$ and I_1 is some integer,

(2) $\bar{d} = I_2 C^n + r_2$, where $0 \leq r_2 < C^n$ and I_2 is some integer.

But,

(3) $d = d^* + \bar{d} = (I_1 + I_2) C^n + (r_1 + r_2)$.

The "if" case is valid since, by hypothesis, either $(r_1 + r_2) = \begin{cases} 0 \\ \\ C^n, \end{cases}$ but in either case $C^n \mid d$.

To show the "only if" case assume the hypothesis and the negative of the conclusion and arrive at the following contradiction:

By hypothesis, there exists an integer I_3 such that

(4) $d = I_3 C^n$.

Therefore, from (3) and (4) $C^n \mid (r_1 + r_2)$. But from (1) and (2), $0 \leq (r_1 + r_2) < 2C^n$, that is, $0 \leq \frac{(r_1 + r_2)}{C^n} < 2$.

The negative of the conclusion asserts that $\frac{r_1 + r_2}{C^n} \neq 0$ and $\frac{r_1 + r_2}{C^n} \neq 1$. Thus we arrive at the assertion that $C^n \not\mid (r_1 + r_2)$.

Corollary 2.1: If $C^n \mid \bar{d}$ and $C^n \mid d^*$, then $C^n \mid d$.

Proof: $r_1 = r_2 = 0$ and apply theorem 2.1.

Corollary 2.2: If

(i) $C \mid B$ or $C \mid a_i$, $(i = n, n + 1, ..., m)$ and

(ii) $C^n \mid d^*$, then $C^n \mid d$.

Proof: If $C \mid B$ *or* $C \mid a_i$, $(i = n, n + 1, ..., m)$ then $C^n \mid \bar{d}$. Now apply corollary 2.1.

Example 2.1:

Does $2^3 \mid 3\ 1\ 4\ 1\ 5\ 9\ 2\ 6\ 5\ 3\ 6$?
Yes! Since $8 \mid 5\ 3\ 6$.

Does $2^4 \mid 2\ 7\ 1\ 8\ 2\ 8\ 1\ 8\ 2\ 8\ 5$?
No! Since $1\ 6 \not\mid 8\ 2\ 8\ 5$.

Summary

Five general propositions dealing with the application of elementary number theory to numerical aspects of symbolic logic and Diophantine analysis are proved. For concreteness, some specific examples are given to demonstrate the use of the propositions.

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COMPARISON OF HABITATS OF TWO CRAYFISHES OF THE GENUS *PROCAMBARUS* IN ILLINOIS AND LOUISIANA

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As part of a study of the biology of the crayfishes of central and southeastern Illinois, the author investigated the aquatic habitats of the crayfishes found in that state (Brown, 1955). The limnological data consisted of records of the temperature of the water, dissolved carbon dioxide, hydrogen-ion concentration, dissolved oxygen, and total alkalinity. Additionally, data were compiled on physical factors such as the general type of habitat, types of bottoms, and the turbidity of the water.

Subsequently, during a study of crayfishes in Louisiana, two forms, *Procambarus clarkii* (Girard) 1852 and *P. blandingii acutus* (Girard) 1852, which also occur in both of these rather widely separated states, were collected. According to Hagen (1870), *P. b. acutus* has been reported in both Illinois and Louisiana over a long period of time, while *P. clarkii* appears to be a relatively recent migrant into Illinois (Brown, 1955). In the light of these facts the author became interested in comparing the habitats of these forms in the two states. It was hoped that such an investigation might clarify the factors responsible for the difference in the distributional pattern and indicate the probability of the success of *P. clarkii* in Illinois.

Materials and Methods

The comparisons of *P. clarkii* are based on only nine collections in Alexander, Massac, and Pulaski counties in Illinois, and records from ten collecting stations in East and West Baton Rouge parishes, Louisiana. On the other hand, *P. b. acutus* was collected throughout Illinois, while the data from Louisiana were obtained from nine stations in East and West Baton Rouge parishes. It is unlikely that these data represent the true range of variation over the entire state of Louisiana. However, it is felt that they are sufficient to serve as a basis of comparison of the types of habitats occupied by these two forms in the two rather widely separated areas.

Standard limnological methods were used (Welch, 1948). Temperature determinations were made with a Centigrade chemical thermometer. La Motte colored glass standards were used for the hydrogen-ion tests. Total alkalinity values were arrived at by titrating .02N sulfuric acid against methyl orange, and the Rideal-Stewart modification of the Winkler Method was used in the determinations of dissolved oxygen. A Kemmerer water sampler was used for collecting the samples for both of these determinations. A nomogram based on Moore's equation (1939) was used to find values for dissolved carbon dioxide. The references to turbidity are estimates of relative clearness of the water rather than to exacting quantitative measurements.

Results and Discussion

Since the temperature of the water varies with the climate, the occurrence of the two forms in the two states, whose mean annual temperatures are quite different, suggests that both forms have a very wide range of tolerance to varying temperatures (Table 1). The data agree with those of Park (1945) ; he found that pond or lentic crayfishes are found predominantly in lentic situations (Table 2). A comparison of the mean temperatures of the waters in which they were found suggests that temperature might be an important factor in that the mean temperature of the water of the habitat differs by only 1.5°C. for *P. b. acutus* and 1°C. for *P. clarkii* in the two states. However, the ranges are based on samplings during the warmer season.

According to Welch (1951), the literature contains numerous positive contentions that pH is an important limiting factor for certain organisms. However, he also points out that other workers regard pH as of secondary importance, and that some investigators have claimed for some organisms no correlations of any sort with the pH range as it occurs in natural, unmodified waters. The latter appears to be true for these crayfishes (Table 1). The mean of the hydrogen-ion concentrations for waters inhabited by *P. b.*

Table 1.—Chemical Data from the Habitats of the Crayfishes.

	Temperature °C		Hydrogen-ion		Dissolved O_2[1]	
	Range	Mean	Range	Mean	Range	Mean
P. clarkii						
Illinois	22–34	27	6.8–8.0	7.3	1–11.3	4.1
Louisiana	20–33	28	6.8–7.6	7.0	1.3–7.4	4.0
P. b. acutus						
Illinois	8–35	23	6.3–8.2	7.2	1–12	5.0
Louisiana	20–33	24.5	6.8–7.6	7.1	1.8–7.4	4.5

	Dissolved CO_2[1]		Total alkalinity[1]	
	Range	Mean	Range	Mean
P. clarkii				
Illinois	1–50	13	59–202	112
Louisiana	0.14	3.8	13–217	59.5
P. b. acutus				
Illinois	0–50	10	50–463	190
Louisiana	0–13	4.2	13–217	88.3

[1] In parts per million.
Illinois data—spring, summer, fall, 1953, 1954.
Louisiana data—spring, summer, 1957, 1958.

acutus in the two states differs by only 0.1 and that of *P. clarkii* by only 0.3. This suggests a preference. Both forms do, however, inhabit waters in the two states whose hydrogen-ion concentrations are about the same, at least during the periods tested.

Both of the crayfishes live in waters whose dissolved oxygen concentration becomes either rather low or very high (Table 1). The dissolved oxygen concentrations range higher in Illinois for both forms because they also occur in streams which have rapids and other means of aeration. The means for both forms in the two states do not appear to be significantly different, varying in the case of *P. b. acutus* by 0.5 p.p.m. and that of *P. clarkii* by only 0.1 p.p.m. These data suggest that both crayfishes live in waters with essentially the same oxygen concentration in the two states.

There seems to be a greater difference in the concentration of the dissolved carbon dioxide than in any of the previous factors. These results may best be explained on the basis of the data from the individual samplings. This is particularly true in the instance of the samplings in Louisiana. In six instances the carbon dioxide concentration was either 1 or 0 p.p.m., and, therefore, the means are low. A comparison of the means of the dissolved carbon dioxide concentrations suggests that this factor may be critical. However, it is also noted that both the means and the ranges are uniformly high for both crayfishes in Illinois and low for both in Louisiana.

The waters in the southern part of Illinois showed lower total alkalinity values than did those of the other parts of the state. *P. clarkii* was found only in the southern part of Illinois. The total alkalinity values for the habitats in Louisiana ran even lower than those of southern Illinois (Table 1). Maximal alkalinity of the waters in Illinois inhabited by *P. b. acutus* ranged up to 463 p.p.m., that of the habitat of *P. clarkii* was 202 p.p.m.; in Louisiana these values were 217 p.p.m. in each case. Therefore, it is seen that the total alkalinity ranges for both *P. clarkii* and *P. b. acutus* in Illinois and Louisiana are rather wide. The total alkalinity values suggest that there is a considerable difference between the habitat preferences of these forms in the two states, but both forms tolerate wide ranges of alkalinity.

Rhodes (1944) wrote that *P. b. acutus* is "rather tolerant regarding ecological factors", and Hobbs and Marchand (1943) usually found *P. clarkii* in lentic situations in Kentucky and Tennessee. During this study both forms were usually found in situations comparable to those reported from other areas. The general types of habitats from which the two forms were collected in both states do not differ greatly. The higher percentage of *P. clarkii* in running water in Louisiana (Table 2) is probably due to abnormally frequent rains while the collections were being made; this resulted in the occurrence of crayfishes in running water in streams which are normally intermittent.

Rhoades (1944) found *P. clarkii* predominantly in mud-bottomed sloughs or temporary situations. The information gained in investi-

gating the two forms in Illinois suggests that both crayfishes seem to exhibit a preference for mud-bottomed situations. The percentages of collecting stations with mud bottoms from which both forms were collected in both states are almost identical (Table 2). The fact that *P. b. acutus* was on sandy and rocky bottoms in Illinois may be attributed to the fact that such habitats are relatively abundant in that state.

The final aspect for consideration is that of turbidity. It was noted while collecting various species of crayfishes that these two forms, in particular, seemed to show a decided preference for turbid waters. During the present study only *P. b. acutus* was found in clear water. With the exception of the instances in which *P. b. acutus* was collected from clear water situations, the turbidity of the waters from which the two forms were collected in the two states is strikingly similar (Table 2).

TABLE 2.—Distribution of Crayfish Related to Physical Factors in the Habitat.[1]

WATER	Running	Intermittent	Pond	Temporary pond
P. clarkii				
Illinois	..	44	12	44
Louisiana	40	20	10	30
P. b. acutus				
Illinois	37	50	7	6
Louisiana	50	12.5	12.5	25

TYPES OF BOTTOMS	Soft mud	Sandy	Rocky	Sand and mud	Clay
P. clarkii					
Illinois	100	..	..	....	....
Louisiana	90	..	..	....	10
P. b. acutus					
Illinois	71	9	5	9	6
Louisiana	75	..	..	12.5	12.5

TURBIDITY	Low	Medium	High
P. P. clarkii			
Illinois	....	34	66
Louisiana	....	60	40
P. b. acutus			
Illinois	15	45	40
Louisiana	12.5	50	37.5

[1] Expressed in percentages of occurrence of crayfish.

Acknowledgments

The author is indebted to Southern University for the use of equipment and facilities for the data from Louisiana. Gratitude is also expressed to Dr. Max R. Matteson of the University of Illinois who supervised the doctoral problem from which the Illinois data were taken and gave valuable advice and suggestions for the other work reported herein.

Summary

The limited section of southern Illinois from which *P. clarkii* was collected affords essentially the same types of physical conditions as those found in Louisiana where this species abounds. This is not true for *P. b. acutus*. The present study, like that of Hobbs and Shoup (1942), showed no evident correlation between alkalinity, pH, dissolved oxygen, dissolved carbon dioxide, or temperature and the distribution of the crayfishes. The data seemed to indicate a marked similiarity of conditions, both physical and chemical, under which the two crayfishes live in the two states. However, the conditions under which *P. clarkii* lives in both Illinois and Louisiana seem to be more nearly the same than do those under which *P. b. acutus* lives in the two states; these conditions might serve as a limiting factor for the further dispersal of *P. clarkii* in Illinois and adjacent areas.

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ECOLOGICAL INTERPRETATION OF DATA ON ARCHAEOLOGICAL SITES: THE MODOC ROCK SHELTER

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Introduction

At the eastern edge of the Mississippi flood plain about two miles southeast of Prairie du Rocher, Randolph County, Illinois, is the Modoc Rock Shelter. It is one of the oldest and longest occupied Indian sites now known in North America. Radiocarbon determinations have indicated that it was occupied as early as 8000 B.C. and inhabited until after 2000 B.C., a time span of over 6000 years (Fowler, Winters and Parmalee, 1956; Deuel, 1957; and Fowler, 1959). During most of its history, the Modoc Rock Shelter was occupied by peoples of the Archaic Stage of cultural development (Willey and Phillips, 1959). Later occupations of the Modoc Rock Shelter were sporadic, and some evidence indicates the site was occasionally utilized by Indians as late as 1200 A.D.

The basic contours of an overhanging bluff were probably formed by the torrential waters from the Valders substage of the Wisconsin glaciation (M.M. Leighton, pers. comm.). This substage reached its maximum around 9000 B. C. (Rubin, 1955: 453). The Modoc Rock Shelter was probably first occupied soon after the flood waters receded, for the first evidence of such occupation was found on bed rock. During the course of human occupation the site built up, through natural and human agencies, to a depth of more than 27 feet above this rock.

The Illinois State Museum conducted archaeological excavations at the Modoc Rock Shelter during the summers of 1952, 1953 (with cooperation of Department of Anthropology, University Chicago), 1955 and 1956. Thousands of artifacts of human manufacture, chert chips, mollusks, animal bones, human burials, and other indications of human habitation were recovered.

Ecological Interpretation of Animal Remains

The large quantity of bone and shell recovered at the Modoc Rock Shelter Site has proved to be of especial significance to both the zoologist and the archaeologist. For the zoologist, the variety of species represented and the number of remains provide an index to the prehistoric distribution and possible abundance of the animals inhabiting or migrating through this area. To the archaeologist, these faunal materials supply food habits data of these Archaic people. The presence of exotic species in the midden deposits suggest trade routes and/or barter, while the occurrence of species typical of a particular habitat indicates the locality hunted by the Indian.

More than 92,000 pieces of bone were removed from these midden deposits; nearly 8,000 bone remains were identifiable to genus or species. Approximately 17,000 shells of fresh-water mussels and terrestrial

and aquatic gastropods were identified. With but few exceptions, all of the species of mussels and animals identified from the midden debris still occur in that general region of southwestern Illinois.

Mollusks

Fresh-water mussels were common at this site and apparently formed an important source of food for the Indian; they would have been easily obtainable and available throughout most of the year. Approximately 2,900 shells of mussels, representing 36 species, were identified, and the majority of these were typical large-river forms and had probably been collected in the Mississippi River. However, the presence of certain species characteristic of shallow, mud-bottomed ponds and sloughs (*e.g. Uniomerus tetralasmus*) suggests that the Indians hunted the shallow backwaters and sloughs as well as the main river for mussels (Parmalee, 1956).

None of the numerous sites previously excavated in Illinois produced the quantity and variety of species of snails recovered at the Modoc Rock Shelter. Although the vast expanse of time involved during the periods of human occupancy would allow for the probable accumulation of such quantities of terrestrial gastropods, the abundance of certain aquatic species (more than 4,400 specimens of *Campeloma* spp.) also points to the use of snails as a source of food. Matteson (1953) concluded that terrestrial gastropods in the midden heap of a Hopewellian site in Pike County, Illinois, ". . . were not an item of diet of the Indians . . . . They became a part of the kitchen midden while seeking food." Probably some of the specimens recovered at the Modoc Rock Shelter occurred there naturally, but the high concentration of aquatic as well as terrestrial forms indicates that snails were eaten.

Of the more than 14,000 identified gastropod shells recovered at the Modoc Rock Shelter less than two dozen bore evidence of having been worked or altered in any way. Four shells of Campeloma and 17 small specimens of *Anculosa praerosa* had been drilled or otherwise modified for use as beads. The latter species is of interest since it apparently occurs only in the lower Wabash and Ohio rivers in Illinois. These 17 specimens were possibly acquired through barter or during wanderings to the southeast. This paucity of worked shell artifacts compared with the huge quantity of mollusk remains suggests that their primary use was for food; in most instances it appears that the various species were collected in direct proportion to their abundance and availability.

Vertebrates

Judging from the variety of fishes, turtles, birds and mammals represented in the midden deposits, the Indian utilized extensively the local vertebrate fauna. In the instance of the whitetail deer, as well as many other species, it is obvious that the animal was intentionally killed for food and/or other purposes. However, the remains of small mammals such as chipmunks and mice which could have inhabited the site area raise the question as to whether or not these forms were eaten by the Indians.

Fishes.—A minimum of ten species of fishes was represented in the

midden debris; bones of the freshwater drum, catfish (*Ictalurus* spp.), gar, bowfin, and catastomids (buffalofish and suckers) were the most numerous. Most of the remains were of small specimens and more than 50% of all those identified were of "rough" fish—gar, suckers and bowfin; the smaller bullheads accounted for approximately 25% of the total. These fishes are known to inhabit commonly the shallower, quiet backwaters and sloughs; therefore, it appears that the Indians obtained most of their fishes from such habitats.

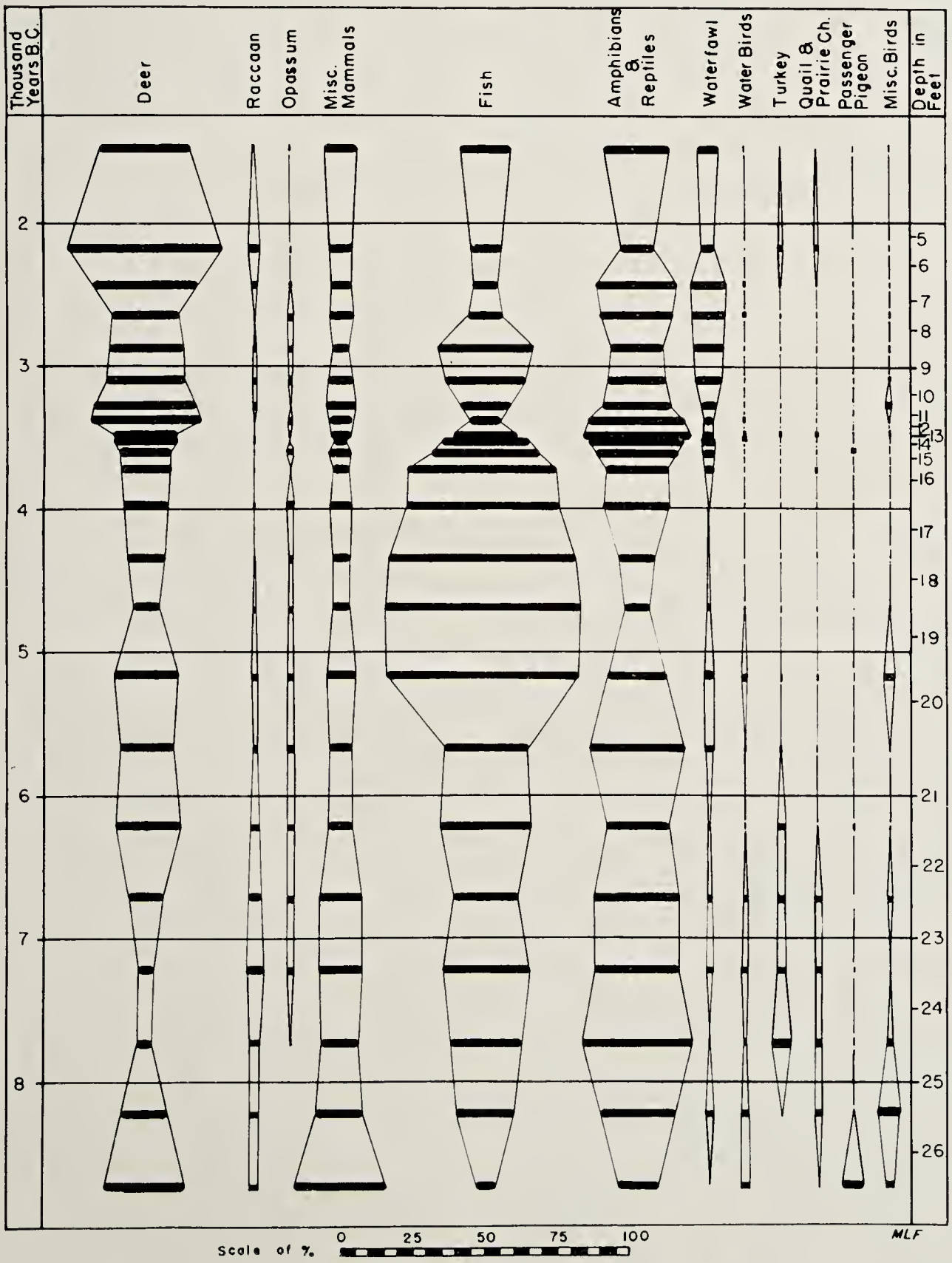

Fig. 1—Distribution of vertebrate remains by depth, Modoc Rock Shelter, Randolph County, Illinois. Length of bar represents proportion of category to total number of vertebrate remains from that depth.

Reptiles.—More than 800 snake vertebrae were found scattered throughout the occupation levels; no specimens were found associated with any of the human burials, and it is a matter of speculation as to whether snakes were eaten by these Archaic people or whether they died naturally at the site.

Turtles were apparently collected in large numbers as indicated by the nearly 2,000 shell fragments and sections. Remains of the locally abundant pond terrapin, *Pseudemys scripta,* and painted turtle, *Chrysemys picta,* were the must numerous. Correlated with the predominence of bullhead and "rough" fish bones, remains of turtles (species especially common in backwater areas) strengthen the hypothesis that the Indians hunted and collected this type of game in the overflow ponds and sloughs. Only eight bones of the soft-shelled turtle were recovered; *Trionyx* more typically inhabits the faster waters of the main river. Box turtles were taken in considerable numbers and, as evidenced by the numerous sections of scrapped and worked shell, the carapace was often used as a dish or utensil.

Birds.—At least 56 species of birds were identified from the more than 900 avian remains found, and it is apparent that this group of vertebrates provided an important source of food. The Modoc Site is situated along the Mississippi River which is one of the major waterfowl flyways; approximately 65% of the identified bird bones were those of ducks, geese and swans. With the occurrence of other aquatic and semiaquatic species such as the pied-billed grebe, American coot, sandhill crane, rails, bitterns, and shorebirds, it is apparent that the Mississippi River and especially the associated backwaters were hunted extensively for avian game.

Although the data indicate that much of the game was taken in river and marsh habitats, remains of species associated with dry upland areas, such as the greater prairie chicken, bobwhite, eastern cottontail and spotted skunk (Parmalee and Hoffmeister, 1957), suggest limited hunting in the prairie and semi-brush areas away from the river. Bones of the extinct passenger pigeon (Parmalee, 1958) were of special interest; these birds were probably captured on the wooded bluffs during migration. In comparison with the total number of identified bird bones, the precentage (7) of turkey bones was small.

Mammals. — The whitetail deer was singly the most important vertebrate species taken by the Indian (approximately 70% of the total identified mammal bones) and it apparently served as the meat staple. Several smaller species such as the muskrat, raccoon, squirrel (*Sciurus* spp.), opossum, and eastern cottontail were taken in considerable quantities and constituted some of the more important supplements of the diet. The first two species were definitely associated with an aquatic habitat, although the squirrels and opossum could have been taken in the wooded uplands or the floodplain forests along the river. A rather extensive use of the opossum by these Archaic people is noteworthy, since remains of this primitive mammal are rare in sites of more recent periods in Illinois.

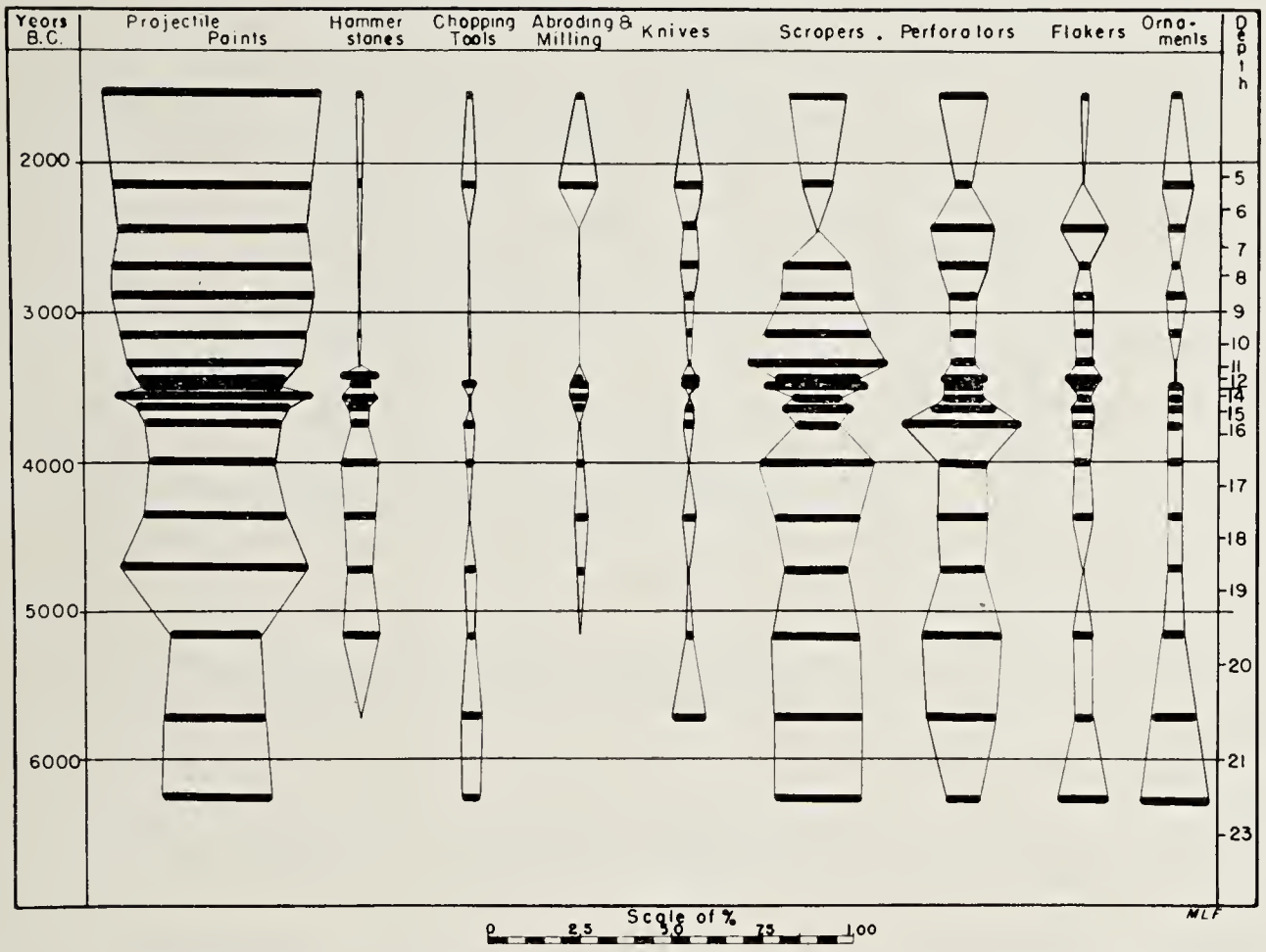

FIG. 2.—Distribution of artifacts by use categories and depth found, Modoc Rock Shelter, Randolph County, Illinois. Length of bar represents proportion of category to total number of artifacts found at that depth.

The presence of such species as chipmunk, mice (*Peromyscus, Microtus*), plains pocket gopher and other small animals often considered as undesirable for food and which could have lived naturally in the area of the site raises the question as to whether or not these forms were eaten by the Indians.

Bone Artifacts

Animals were taken primarily for food although in many instances bones of one or more species served in a secondary capacity as ornaments, tools or utensils. Several artifacts manufactured from deer antlers (tines, flakers) and limb bones (*e.g.* awls fashioned from the ulna) were not uncommon while bone splinter awls occurred throughout most occupation levels. The tarsometatarsus of the turkey was also used to make awls. One of the most unique finds was a cache of approximately 160 goose (*Branta canadensis* and *Chen* spp.) radii and six tarsometatarsals of the sandhill crane associated with a human burial. Some of the radii had been made into awls but the majority were not altered. This find probably was a cache of raw materials for making awls, placed as a grave offering.

Ecological Conditions

The data indicate that ecological conditions were much the same throughout the history of the site. The well-represented species of animals were present in most levels of the site. One notable exception to this was the presence of the terrestrial gastropod, *Allogona profunda*, only in the lowest strata; presently this species occurs only in the north-

TABLE 1.—Vertebrate Remains from Modoc Rock Shelter: Mammals, Fishes, Amphibians and Reptiles.

Depth, feet	Mammals					Fishes	Amphibians, reptiles
	Deer, Elk	Raccoon	Opossum	Others	Unident.		
Above 5	115	7	1	47	3102	65	86
5-6	72	6	1	10	1381	15	16
6-7	100	6	1	17	1918	22	80
7-8	207	11	14	67	5885	193	236
8-9	503	45	66	138	2872	770	425
9-10	399	35	19	122	9328	388	292
10-11	342	18	10	95	7246	166	220
11-12	140	6	2	27	3342	41	125
12-13	95	3	5	31	2968	100	164
13-14	249	14	9	53	7051	338	370
14-15	139	5	3	57	4862	301	220
15-16	115	4	14	37	3854	332	144
16-17	96	7	1	43	4555	317	138
17-18	99	9	.....	50	4087	485	106
18-19	68	10	10	37	3345	494	63
19-20	57	8	5	27	2603	179	54
20-21	67	6	6	28	2517	104	117
21-22	60	10	5	23	1915	99	59
22-23	34	12	9	25	1548	58	77
23-24	7	7	3	17	664	37	35
24-25	8	7	2	21	1101	36	60
25-26	12	3	.....	13	336	16	20
26-27	6	1	.....	7	134	2	1
27-28	2	.....	.....	2	24	.....	3

TABLE 2.—Vertebrate Remains from Modoc Rock Shelter: Birds and Totals.

Depth, feet	Birds							Totals	
	Waterfowl	Water birds	Turkey	Quail, prairie chicken	Passenger pigeon	Misc.	Unident.	All	Ident.
Above 5	23	1	2	0	1	5	60	3,515	353
5-6	6	0	2	2	0	1	23	1,535	131
6-7	36	3	2	3	2	1	115	2,306	273
7-8	114	13	8	9	2	14	396	7,169	888
8-9	268	16	12	17	3	35	863	6,033	2,298
9-10	135	8	3	8	1	27	513	11,278	1,437
10-11	47	5	2	7	0	22	180	8,355	929
11-12	11	3	2	1	0	2	69	3,771	360
12-13	16	5	5	4	2	6	96	3,500	436
13-14	53	18	3	3	2	11	321	8,495	1,123
14-15	35	2	4	3	16	9	268	5,924	794
15-16	25	3	2	6	1	2	120	4,659	685
16-17	5	1	4	4	4	6	69	5,250	626
17-18	8	4	2	2	1	1	63	4,917	767
18-19	10	1	4	1	0	2	47	4,092	700
19-20	11	4	2	2	1	9	38	3,000	259
20-21	13	3	3	1	1	3	43	2,912	352
21-22	4	2	7	2	2	1	46	2,235	274
22-23	4	4	6	5	0	5	56	1,853	249
23-24	3	3	4	3	1	0	12	796	120
24-25	1	2	8	3	1	3	30	1,283	152
25-26	2	2	0	2	1	6	10	423	77
26-27	.....	1	0	.....	1	1	12	166	20
27-28	.....	.....	.....	.....	1	.....	.....	32	8
								92,504	13,311

ern half of Illinois and is associated with a cool, damp, wooded habitat. This may correlate with the geological data which indicate that the site was first occupied soon after the Valders Substage of the Wisconsin glaciation reached its maximum.

Although remains of a few species suggest the utilization of upland prairie and semi-bushy regions by the Indian, the majority of the animals were apparently taken in the forested flood plain and backwater habitats of the Mississippi River. At the present time, therefore, interpretation of the faunal data leads to the conclusion that the local habitat remained relatively unchanged with the exception of earlier periods which were apparently somewhat cooler and damper.

Correlation of Artifacts With Animal Types

To study any possible changes in the use of fauna through time, the vertebrate remains were divided into broad categories as well as species. The proportion of each of these categories (Tables 1 and 2) to the total number of vertebrate remains was calculated for each one-foot level of the site. These proportions were plotted on a graph (Fig. 1) with the levels spaced on a time axis as indicated by the radiocarbon assessments.

In the periods of the earliest occupation of the site (8000-6000 B.C.), the inhabitants made use of practically all animals available to them for food. For example, the category of miscellaneous mammals was more strongly represented in that period than in any later periods. Birds, with the exception of waterfowl, were more common in the midden debris of the lower levels than in the upper strata.

In the middle periods of the site's occupancy (6000-3000 B.C.) fishes dominated the remains, thus indicating that they were used more extensively for food than previously. A separate analysis of the mollusks by one-foot levels indicated that this was also the period when aquatic snails and clams were most extensively utilized at the Modoc Rock Shelter.

In the later period of the Archaic habitation (3000-2000 B.C.), all categories decreased except deer and waterfowl; remains of these animals became much more plentiful. This suggests that the Modoc hunters had become more selective in hunting and that, perhaps, the Modoc Rock Shelter became a hunting camp occupied only in the fall of the year when deer and waterfowl would have been most abundant.

A similar analysis was undertaken of the artifacts found at the different levels. These artifacts were broken down into use categories to indicate the different activities of the people. The analysis of these categories (Table 3) was carried out in the same way as described above for the vertebrate remains. The proportions of each of these tool categories for the various levels are shown in Figure 2. There are no data from before 6500 B.C. since, for this type of analysis, too few artifacts were found in the lower levels.

Projectile points, suggesting hunting activities, increased through time, and between 3000-2000 B. C. they accounted for more than 50%

TABLE 3.—Analysis of Modoc Assemblage by Use Categories.

Depth, feet	Projectile pts.	Hammer stones	Chopping tools	Milling, abraders	Knives	Scrapers	Perforators	Flakes	Ornaments	Totals
Above 5	40	.....	1	1	.....	11	9	2	3	67
5-6	14	1	1	3	2	2	1	.....	2	26
6-7	20	.....	.....	.....	2	4	7	5	1	39
7-8	80	1	1	1	6	28	21	5	3	146
8-9	135	3	1	1	8	50	19	16	13	246
9-10	124	7	4	1	6	69	16	131	8	240
10-11	118	3	2	.....	2	103	19	11	2	261
11-12	31	9	1	.....	3	17	9	8	1	78
12-13	39	5	3	2	4	30	10	6	4	103
13-14	64	12	1	6	1	16	12	3	3	119
14-15	35	4	1	4	2	16	15	4	3	84
15-16	30	4	2	2	2	5	26	5	2	78
16-17	38	13	4	.....	.....	34	14	4	4	114
17-18	38	8	.....	2	4	22	14	5	4	97
181-9	37	5	2	2	1	13	9	1	3	73
19-20	12	5	1	1	1	12	11	3	3	49
20-21	12	.....	2	.....	4	10	8	2	5	43
21-22	6	.....	1	.....	.....	5	2	3	4	21

of the tools. Domestic tools, indicating various manufacturing and living activities such as hammerstones, chopping tools, perforators and scrapers, were most common in the period between 6000 and 3000 B.C. but negligible from 3000 to 2000 B.C. Knives or cutting tools, although well represented between 6000 and 5000 B.C., had their strongest consistent representation between 3000 and 2000 B.C., the same as projectile points. Ornaments were most common around 6000 B.C. and decreased proportionally thereafter.

The analysis of the artifacts indicates that the Modoc Rock Shelter was a general habitation site between 6000 and 3000 B.C. and that many different hunting and domestic activities were carried on there. After 3000 B.C., projectile points and knives, *i.e.* hunting tools, became more important and other activities were negligibly represented. These data correlate with the analysis of the faunal data which points to the probability that in the earlier periods, the Modoc inhabitants hunted and gathered a great variety of wild food. In the middle period they utilized more extensively freshwater mussels, snails, and fish which were locally available. In the late period they tended to specialize in the hunting of deer and waterfowl.

In terms of the process of adaptation to the local environment, the human habitation of Modoc Rock Shelter can be divided into three sequent phases based upon the data on the fauna and artifacts presented above: *Phase I*) The Initial Occupation (8000-6000 B.C.). The site was first occupied by people who utilized all food resources available; *Phase II*) The Period of Localized Adaptation (6000-3000 B.C.). In this phase the Modoc inhabitants learned to supplement more extensively their staple deer meat diet with other food sources available in the immediate area. These were fish, clams, and snails in the tributaries, backwaters and sloughs of the Mississippi River; *Phase III*) The Period of Specialized Adaptation (3000-2000 B.C.). In this phase the Modoc inhabitants became specialists in hunting deer and waterfowl and probably occupied the site primarily as a hunting camp. Previously it had been a general habitation area. They probably carried on other activities in different specialized camps and at different seasons of the year. Exemplary of such other specialized camps would be the Ferry Site in Hardin County, Illinois (Fowler, 1957), where the tools indicated that it was a nut collecting, manufacturing, and ceremonial site. Another type of site was the large shell middens in Kentucky (Webb, 1946) which indicates that the collection of mussels (probably in the summer when rivers were at low level) was the basis of subsistence.

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INTERRELATIONS BETWEEN EMPIRICAL FORMULAE FOR SPECTROSCOPIC CONSTANTS OF DIATOMIC MOLECULES

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Introduction

The spectra of diatomic molecules have been studied to obtain the values of certain constants which characterize the structure of a molecule and its energy levels. The variation of potential energy, U, as a function of the internuclear distance, r, may be represented graphically by the conventional potential energy curve.

Not all spectroscopic constants are known for all molecules or even for all states of a single molecule. Various empirical relations have been proposed to predict the values of unknown constants from those known experimentally. These relations have also been used to provide insight into bonding models of molecules. Examples of these relations are found in the early work of Badger (1934) and the recent work of Smith (1956). In general, specific relations have been used to make predictions for molecules which have some common characteristics.

In this paper some of the empirical relations are examined as to their range of validity. Some standard techniques of mathematical treatment of experimental data are applied to these relations to determine whether *a priori* a certain empirical relation will be more valid than another relation. These techniques are also used to suggest two new empirical relations which should be of use in prediction of unknown spectroscopic constants.

The following notations are used to represent the various spectroscopic constants: 1) r_e, internuclear distance at the equilibrium distance; 2) D_e, dissociation energy; 3) k_e, force constant; 4) α_e, constant related to the rotational constant, B_e; 5) $\omega_e x_e$ and 6) $\omega_e y_e$, both of which are constants related to the anharmonicity (*i.e.*, the deviation from a true parabola at the equilibrium minimum).

Relation to Analytical Expressions

Many investigators have sought to express the experimental potential energy curve as a mathematical equation. This has been done in both open and closed form. The closed expressions have been selected to reproduce the general shape of the curve, to obey certain limiting conditions (*cf.* Varshni, 1957), and to reproduce certain of the known spectroscopic constants. These known constants are either placed directly in the mathematical expression or used as boundary conditions to determine the values of the arbitrary constants used in the mathematical equation. In general, the more arbitrary or fixed constants which are used in the mathematical equation, the better is the "fit" to the experimental curve. In the literature, equations are found containing as few as two constants (Kratzer, 1922) and one with five constants (Hulburt and Hirschfelder, 1941).

Dunham (1932) proposed a mathematical equation in the form of a Taylor series. Although this expression has poor convergence properties, it does have the advantage of allowing flexibility in the choice of the number of constants used to "fit" the experimental curve. Dunham has also shown that the coefficients of the power series are related to the known spectroscopic constants. For example, the coefficient of the square term (the second derivative of the equation divided by two factorial) is equal to k_e.

The application of Dunham's formulae to the closed form expressions leads to analytical expressions between the known spectroscopic constants. These analytical expressions are identical in functional form to the empirical relations between spectroscopic constants proposed by various authors. However, it is not necessarily true that an equation which is a good "fit" to the experimental curve will produce a functional relation between known constants which is also good. In fact, these functional relations being derived from differentiation depend on the positioning of the constants in the analytical expression for the experimental curve. They also depend on whether arbitrary constants are used and adjusted to the boundary conditions or whether the known constants are placed in the analytical expression directly.

The analytical expression of Mecke (1927), Sutherland (1938), Varshni (1957), and Kratzer (1922) all lead to the relation

$$\frac{k_e r^2_e}{D_e} = C_2 \qquad (1)$$

where C_2 is a constant. The original expressions,

$$U = D_e \left[\frac{r - r_e}{r} \right]^2 \quad \text{Kratzer}$$

$$U = Ar^m e^{-ar} \quad \text{Varshni}$$

$$U = Br^{-m} - br^{-p} \quad \text{Mecke-Sutherland}$$

where A, a, B, b, m, and p are arbitrary constants, are examples of a two-parameter function, a three-parameter function, and a four-parameter function, respectively. The value of C_2 should be the same for all molecules. In practice, the value of C_2 differs when individual molecules, or groups of molecules, are considered. The functional form of C_2 which relates the known constants is the same. Thus, the more flexible Mecke-Sutherland equation, which would be expected to give a more faithful representation of the experimental curve, provides the same relation between k_e, r_e, and D_e as the less flexible Kratzer equation.

Comparative Test of Various Empirical Relations

The spectroscopic constants vary from a fivefold range (for r_e) to a thousand fold range (for α_e) for all molecules. An empirical relation that could be used to predict a spectroscopic constant would be expected to make predictions within a smaller range than the naturally occurring variation. The best relation would satisfy all possible diatomic molecules, but several useful relations have been found which satisfy certain groups of molecules.

The general procedure adopted in this work is to "fit" a particular group by finding the best arbitrary

constant for that group when the relation is put into a functional form similar to equation (1). The best constant is also determined for all molecules. The average deviation from these constants is tabulated in Table 1. (A random sampling indicated that a Least Squares Deviation treatment did not change general ordering of the empirical relations with respect to deviation from a good "fit".) A sample of 21 diatomic molecules was selected. No attempt was made to select molecules which had normal behavior in their spectroscopic constants. In fact, molecules were used (N_2, CO, and NO) whose D_e is in doubt, as well as molecules which are known to have abnormal values of the spectroscopic constants (Li_2, Na_2, and K_2). The values of the spectroscopic constants used in these tests were taken from the values tabulated by Varshni (1957). The molecules were grouped according to similar chemical properties, as indicated by the Periodic Table. In each grouping of homopolar molecules, the atoms were selected from a given row or column of the Periodic Table. In each grouping of heteropolar molecules, one atom was selected from a given row or column and the other atom was the same throughout the grouping. The molecules comprising each group are listed in Table 1.

A comparison between the constancy of r_e ($r_e = C$) and $k_e r_e^2 = C_1$ is given in Table 1. The combination of two constants gives a much better "fit" within a given grouping of molecules but provides a worse "fit" when an attempt is made to

TABLE 1.—Comparison of Average Percentage Deviations.

Molecular groupings	C	C_1	C_2	C_3	$Ar_e^{-1} + B$	$-L'$	M'
Group VIIA-hydride (HF, HCl, HBr, HI)	16	1	21	13	1	9	11
Group IA-Group IA (Li_2, Na_2, K_2)	14	7	19	10	2	9	20
Group VA-Group VA (N_2, P_2)	27	16	17	36	..	5	13
Group IIB-hydride (ZnH, CdH, HgH)	4	4	24	21	17	17	28
Group VIIA-Group VIIA (Cl_2, Br_2, I_2, ICl)	8	2	14	8	7	8	10
Period 2-oxide (CO, NO, O_2)	3	12	17	14	10	6	7
Period 2-hydride (CH, OH, HF)	8	13	11	11	11	1	1
All molecules	34	59	46	38	2000	28	38

use a single constant for all molecules.

The deviations from a constant of an empirical relation combining three spectroscopic constants is also given in Table 1. This is the C_2 of equation (1). The values of the deviations from C_2 are much greater within a group than are those of C_1 but somewhat better for all molecules. This better behavior when all molecules are considered is fortuitous, as can be seen by examination of the column which gives the deviations for the two parameter relation, $k_e D_e^{-1} = C_3$. In general C_3 is better than the three-parameter relation, C_2, within selected groups and also is better when all molecules are considered.

The conclusion indicated is that the spectroscopic constants may be combined in empirical relations which are reasonably accurate in predicting the values of one constant, in a given grouping of molecules. This appears to result from a fortuitous compensation in variation of the spectroscopic constants themselves. A good relation is obtained only by a judicious grouping of the original constants and does not depend on the number of constants used in the relation. In general, the opposite behavior is observed in selecting a closed relation to represent the potential energy curve.

The usual techniques of "fitting" experimental data (Scarborough, 1955: 473) to an empirical relation employ two arbitrary parameters to give a better "fit" than one arbitrary parameter and three to give a better "fit" than two, and so forth. The analytical expression of Frost and Musulin (1954a) leads to an empirical relation of the functional forms $k_e D_e^{-1} = A r_e^{-1} + B$. Previously a single constant, C_3, was used to describe the product $K_e D_e^{-1}$. This new functional form "fits" the product $k_e D_e^{-1}$ to a straight line function of r_e^{-1} by the use of two arbitrary constants, A and B. The constants A and B are determined in each grouping of molecules by the means of known experimental data. The deviations from a straight line are shown in Table 1. These deviations indicate that the adjustment of data to two arbitrary parameters does create a better "fit" to the data for molecules within a group but is much worse when one tries to fit all molecules to a single straight line.

The data indicate that it is possible to employ the usual mathematical techniques of obtaining a better "fit" to the data with an increased number of arbitrary parameters, within groupings of molecules. These data and those of the preceding columns also seem to indicate that one cannot obtain a good "fit" to both groupings of molecules and to all molecules at the same time. In fact, these results lead to a generalization of Varshni's (1957) statement that "there are no 'universal' relations connecting α_e and $\omega_e x_e$ with Δ" (the Sutherland parameter involving k_e, r_e, and D_e).

A second method of introducing a second arbitrary parameter was shown by Badger (1934) and Sutherland (1940). A term $(r\text{-}d)$ is used in their empirical relations where d is an arbitrary parameter. (There is some indication that this distance parameter may be correlated to the row of the Periodic

Table to which the constituent atoms of the diatom belong). Frost and Musulin (1954b) have also obtained relations introducing a second arbitrary parameter in this manner. Again the use of a second arbitrary parameter improves the "fit" within groupings of molecules, but this method of introducing the second parameter appears to also improve the "fit" for all molecules (Frost and Musulin, 1954b).

Two New Empirical Relations

Frost and Musulin (1954b) derived two new constants L and M, related to the third and fourth derivatives of the potential energy curve (and hence to α_e and $\omega_e x_e$, respectively). If one allows the second arbitrary parameter (the distance parameter) to go to zero in the expressions of L and M of Frost and Musulin (1954b), the following relations may be derived:

$$L' = \frac{\alpha_e \omega_e}{B_e^2}$$

$$M' = \frac{\omega_e x_e}{B_e}$$

where ω_e is the fundamental frequency, L' and M' are constants, and the other symbols have the significance previously given.

Since these are first order approximations, one would expect them to be less valid for all molecules. The preceding analysis would indicate that there might be an expectation that L' and M' would yield relations which would be consistent within certain groupings of molecules but not as good for all molecules. The deviations of L' and M' from constants in Table 1 do indicate that this is the case. These two new constants should prove useful in predicting values of α_e or ω_e and $\omega_e x_e$, although the relations would not be expected to hold for all molecules or for all states of a single molecule. The "fit" for all molecules is surprisingly good when compared to the other data in Table 1. M' does not appear to be as consistent as L', but this is not surprising when one considers that successive derivatives of the potential energy curve are more sensitive to errors (Frost and Musulin, 1954b).

Table 2 gives a comparison of the "fit" of L' and M' compared to L and M for the molecules given in the paper of Frost and Musulin (1954b). This table indicates that the first order approximations are not as good when considering all molecules, but in some instances the fortuitous compensations do give better "fits" within groupings of molecules.

Table 2.—Comparison of Average Percentage Deviations.

Molecular groupings	—L	—L′	M	M′
Group IA-Group IA	7	9	42	20
Group IIB-hydride	1	17	15	28
Group VIIA-Group VIIA	7	8	18	10
All molecules	12	31	42	39

An interesting aspect of these calculations is that the various empirical relations seem to be particularly valid, in many instances, in a given period of the Periodic Table. That relations of this type hold in periods, for polyatomic molecules, has been shown recently by Heath, *et al.* (1950).

Summary

An equation giving a good representation of the potential energy curve does not necessarily provide a good relation between spectroscopic constants. In fact, it appears that a "good" relation between these constants occurs only because of the cancellation of variation in the constants. The usual mathematical methods of providing a better "fit" to a set of experimental data does lead to relations which are very useful for predicting values of unknown spectroscopic constants. This gain in usefulness is made only at the expense of losing a relation which will fit all molecules. This reasoning is used to derive two new relations useful in predicting the values of α_e or ω_e, and $\omega_e x_e$.

The use of empirical constants will continue to be useful to estimate spectroscopic constants in diatomic molecules and polyatomic molecules, but it does not seem possible to relate the varied spectroscopic behavior of many molecules or to ascertain by semi-empirical or mathematical analysis whether a given relation will be more useful than another.

Acknowledgment

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DROSOPHILA OF THE MONTGOMERY ARBORETUM, ILLINOIS

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A study of wild *Drosophila* of the Montgomery Arboretum, DeKalb County, Illinois, was undertaken to determine the species present and their relative abundance.

Two collecting sites were established in the Arboretum, which is a "mixed deciduous mesophytic" forest. Along the northern margin of the Arboretum is a small stream that flows in an easterly direction. On the south side of this stream is a flood-plain approximately 12 feet wide. Collecting site No. 1 was located about 100 feet west from the eastern end of the Arboretum and about 8 feet from the stream. Within a 15-foot radius of this site the dominant type of vegetation is basswood (*Tilia americana*), hawthorn (*Crataegus* sp.), members of the mint family *Labiatae*, and various members of the grass family *Graminae*.

Collecting site No. 2 was located in the southwest corner of the Arboretum, approximately 150 feet from the bisection of Lincoln highway and Normal road. Here, the vegetation was fairly dense and afforded protection from wind and sun. The predominant form of vegetation within a 15-foot radius of the site appeared to be black cherry (*Prunus serotina*), buckthorn (*Rhamnus caroliniana*) and wild geranium (*Geranium maculatum*).

Methods

Mashed and fermenting bananas were used as bait, set out in five-gallon cans fitted with covers which were held slightly off the tops of the cans. This gave the flies free access to the food and protected the bait from inclement weather. Collections were made at both sites, approximately at sunset from May 17 through July 8, 1959. Identifications were made from Sturtevant's key (1942).

Results

A total of 2,065 flies was examined from site No. 1, of which 1,925 or 93% were members of the *D. affinis* species group. Next most frequent was *D. robusta* with 77, or 3.7%. The other species found were: *D. melanogaster*, 27 or about 1%; *D. melanderi*, 19; *D. putrida*, 10; *D. transversa*, 5; and *D. buskii*, 2%.

At site No. 2, a total of 2,028 flies was examined; 1,851 or 91% belonged to the *D. affinis* species group. The next most numerous was *D. robusta* with 82, or 4% of the total. Other species found were: *D. melanogaster*, 59, or about 3%; *D. transversa*, 21; *D. immigrans*, 5; *D. putrida*, 4; *D. melanderi*, 3; *D. tripunctata*, 2; and *D. buschii*, 1%.

Discussion

Although *Drosophila* is best known for its use in studies of problems of heredity, it has of recent years become important in investigations of organic evolution through genetic studies of wild populations (Spencer, 1950). However, as a

first step in studies of wild populations, it is necessary to determine species present and ways to collect them.

From June, 1938, through October, 1942, J. T. Patterson made extensive collections of *Drosophila*, primarily in southwestern United States. He made only scattered collections in the South and Midwest; the only state in the Midwest included in his collection records is Ohio. Patterson's list of species for Ohio contains 32 species found throughout that state. This includes six species Spencer found near Wooster, Ohio. Of the nine species identified in the Montgomery Arboretum, eight are found in Ohio.

Further details of site and methods and a more extended discussion are available in Knez (1959).

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POPULATION RELATIONSHIPS OF SPIDER MITES AND TYPHLODROMID MITES ON APPLE TREES IN CENTRAL ILLINOIS

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Much controversy exists on the importance of species of typhlodromid mites (family Phytoseiidae) as predators of spider mites (Beglarov, 1957; Collyer, 1956; Clancy and Pollard, 1952; Huffaker, 1958; Lord, 1949 and 1956; Marshal and Morgan, 1956; and many others). Interactions between spider mites, their predators, and their environments are extremely complex. It is the purpose of this paper to present a few observations on the densities of spider mites and typhlodromid mites found on apple trees.

Methods

Henderson and McBurnie (1943) designed a brushing machine which has proved highly successful for rapidly estimating spider populations. Morgan *et al.* (1955) found that this machine removed 100% of the active stages and 98.8% of the eggs of spider mites on leaves of Delicious apple trees. Morgan *et al.* reported the same efficiency in the removal of eggs and active stages of typhlodromid mites and other predaceous mites. In every case they found more typhlodromid mite eggs by using the Henderson and McBurnie brushing procedure than were recorded by direct observation with the aid of a microscope.

I have used the Henderson and McBurnie brushing machine procedure since 1953 and have found it satisfactory for estimating spider mite populations; however, typhlodromid mites move more rapidly and are more easily disturbed by light and jarring than are spider mites. These factors reduce the effectiveness of the brushing machine procedure for estimating populations of typhlodromid mites. Often direct counts gave population estimates several times higher than the brushing machine procedure. In this study I have, therefore, used the more direct method of hand picking the leaves and counting the numbers of mites present on the leaves, with the aid of a microscope.

During the spring and summer of 1954, 1955, 1956, and 1957, samples were collected at intervals of about one week from three lots of Jonathan apple trees at Urbana, Illinois. Each lot consisted of four trees of nearly the same age and size. The samples consisted of 25 leaves picked at random from each tree in each lot. The 100 leaves from each lot were put in a plastic bag and taken to the laboratory where the mites were counted within 30 minutes after sampling time.

The first lot of trees received no chemical treatment during the four years of the study and presumably in years preceding the study. These trees will be referred to as "unsprayed".

The second lot of trees was incidentally sprayed with DDT in the course of a Dutch elm disease control program. This program started

in 1949 with two foliar applications of 6% DDT with a mist blower and continued until 1954 when a 12% DDT prefoliar treatment was substituted for one of the foliar treatments. In 1955, 1956, and 1957, only a 12% DDT prefoliar spray was used. The apple trees in this lot will be referred to as "DDT treated".

Although there was year-to-year variation, the third lot of trees received treatments on approximately the following schedule each of the four years of the study:

Dormant: DN 289, 2 qts. per 100 gals. water.

Prepink: (about April 20-30) lime sulfur, 2.5 gals., or organic mercury according to directions on the label, plus microfine sulfur, 4 lbs., or Vancide M, 2 lbs. per 100 gals. water.

Pink: (about first week in May) 2 lbs. lead arsenate, 2 lbs. Vancide M or 3 lbs. microfine sulfur and 1 lb. additional fungicide.

Calyx: (in mid-May) lime sulfur 2.5 gals. per 100 gals. water.

6 or 7 Cover Sprays: (ending in August) 2 lbs. DDT 50% W.P., 2 lbs. lead arsenate (stopped in June) various fungicides, and 2 lbs. malathion 25% W.P. per 100 gals. water.

These trees will be referred to as receiving a "recommended control program".

Observations on Predators

Typhlodromus pomi (Parrott) and *T. rhenanus* (Ouds.) appear to be the most important spider mite predators on apple trees in central Illinois. About 91% of the predators on the unsprayed trees were *T. rhenanus,* about 60 % on the DDT treated trees were *T. pomi,* and about 38% of the predators on the trees receiving a recommended control program were *T. pomi.* The other observed predators were: a snout mite, *Bdella depressa* Ewing; an undetermined mite belonging to the family Raphignathidae; a thrip, *Scolothrips pallidus* (Beach); an aphis-lion, *Chrysopa* sp.; and four species of ladybird beetles, *Adalia bipunctata* (L.), *Cycloneda munda* (Say), *Hippodamia convergens* Guer., and *Stethorus punctum* (Lec.).

Population Relationships

Figure 1 shows the number of *Typhlodromus rhenanus* and the total number of spider mites per 100 leaves on the samples from the unsprayed trees for the four seasons. In 1954, 1956, and 1957, spider mites were not found until July or August, and did not become abundant enough to cause damage. In 1955, spider mites were present in June and became abundant enough to cause damage during July. During the three years in which no spider mite damage occurred, *T. rhenanus* was collected before the spider mites appeared and was present in about a one to one predator-prey ratio. In 1955, when the spider mite damage occurred, the spider mites got the jump on the predaceous mite in June. However, *T. rhenanus* became abundant about two weeks later and the spider mite population dropped rapidly. Thus it seems there is a relationship between low spider mite populations and the presence of *T. rhenanus.* The only species of spider mite occurring on the unsprayed trees was the two-spotted spider

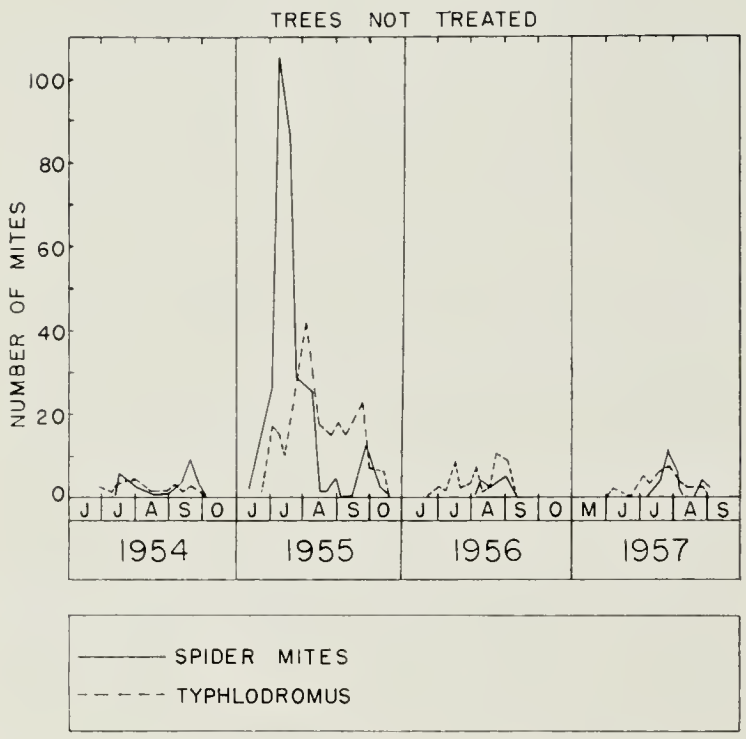

Fig. 1.—Number of spider mites and typhlodromid mites per sample of 100 apple leaves on untreated trees.

mite, *Tetranychus telarius* (L). It comprised 41.4% of the mite population for the four years; the rest of the mites were *Typhlodromus rhenanus*.

Figure 2 shows the number of *T. pomi* and the total number of spider mites per 100 leaves on the samples from the DDT-treated trees for the four seasons. In all four seasons the spider mites caused serious injury to these trees. This was evidenced by bleached appearing leaves and by spots and streaks of dead leaf tissue. Most of the damage was caused by the clover mite early in the season. In August and September of all four years, the two-spotted spider mite became abundant enough to cause injury. The clover mite, *Bryobia praetiosa* Koch, made up 87.3%, the two-spotted spider mite 7.9%, the European red mite, *Panoychus ulmi* (Koch), 0.2%, and *T. pomi* 4.6% of the total four-year population of these species. The ratio of *T. pomi* to spider mites was about 1:27 on the DDT-treated trees.

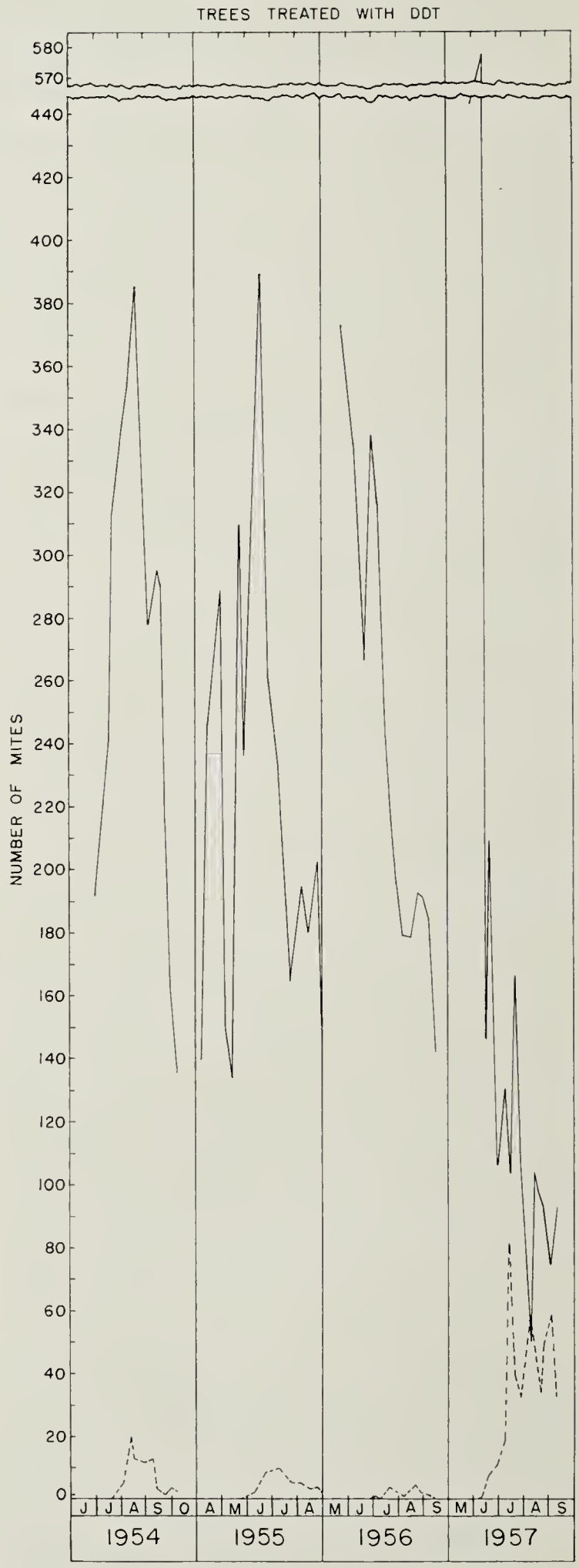

Fig. 2.—Number of spider mites and typhlodromid mites per sample of 100 apple leaves on trees treated with DDT.

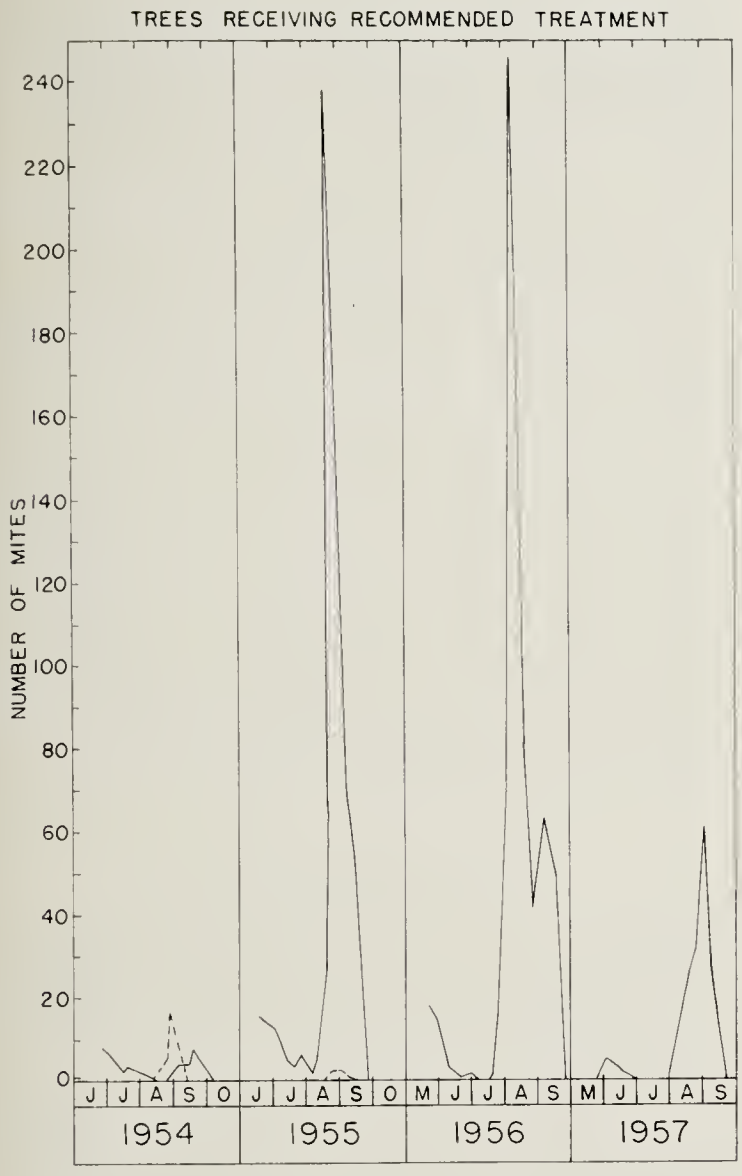

FIG. 3.—Number of spider mites and typhlodromid mites per sample of 100 leaves on trees treated with a recommended orchard spray program, including DDT and malathion.

Figure 3 shows the number of *T. pomi* and the total number of spider mites per sample of 100 leaves on the trees managed under a recommended control program for four years. In 1956 and 1957 no *T. pomi* were collected on these trees. In 1955 and 1956 the two-spotted spider mite caused injury in August and September. Under this control program, 77.2% of the total number of mites present were the two-spotted spider mites, 11.5% clover mites, 8.9% European red mites, and only 2.4% were *T. pomi*. The ratio of *T. pomi* to spider mites was about 1:44 on these trees.

Effects of Spider Mites on Fruit Yields

The average annual yield of fruit was estimated to be 0 to 0.25 bushels per tree on the unsprayed trees, 0.25 to 2 bushels per tree on the DDT-treated trees, and 2 to 5 bushels per tree under a recommended control program. The quality of fruit was superior under the recommended control program, because of less disease and insect damage.

Discussion

On apple trees that had no chemical treatment, spider mites were not abundant enough to cause damage, except on one occasion. In the absence of chemical treatment, *T. rhenanus* appears to be an effective predator of the two-spotted spider mite, *Tetranychus telarius*. On the trees treated with DDT, the clover mite, *Bryobia praetiosa*, was a serious problem in the spring, and the two-spotted spider mite was a problem during the summer. On the trees receiving recommended treatment, spider mite damage occurred during the last half of the season in two years and was for the most part caused by the two-spotted spider mite. The clover mite and the European red mite appeared as potential problems, but caused little damage. On the DDT-treated trees and on trees receiving a recommended treatment, the principal predator was *Typhlodromus pomi*, rather than *T. rhenanus* as on the trees receiving no chemical treatment.

Ristich (1956) reported complete or nearly complete kills of *T. fallacis* (Garm.) with DDT, parathion, chlorobenzilate, Systox, lindane, tox-

aphene, Ovex, heptachlor, dieldrin, and malathion. Huffaker and Kennett (1953) found that Systox, TEPP, parathion and Ovotran were harmful to *T. reticulatus* Ouds. I have also found aramite, malathion, and DDT harmful to typhlodromid mites. Huffaker and Kennett further reported that in their parathion-treated strawberry plots, *T. reticulatus,* a very effective predator of the cyclamen mite (*Tarsonemus pallidus* Banks), was replaced by *Typhlodromus occidentalis* Ouds., a parathion-tolerant predatory mite. *T. occidentalis* was found to be a less effective predator of the cyclamen mite than *T. reticulatus.* It seems that a parallel case occurs on the apple trees which I have studied. *T. rhenanus* appears to be an effective predator of spider mites, but appears to be eliminated by chemical treatment. *T. pomi* seems to be more tolerant of chemical treatment, but is a poorer predator than *T. rhenanus.*

Summary

These observations indicate that predation by *Typhlodromus rhenanus* has a deterrent action on the development of infestations by spider mites. Chemical treatments tend to change the proportional relationships of typhlodromid mites to prey species, the species of typhlodromid mites present, and the proportional relationships of typhlodromid mites to other predators. The replacement of *T. rhenanus* by *T. pomi* results in greater spider mite damage or a greater potential toward spider mite damage on the chemically treated trees. The advantage of natural control, however, is outweighed by the production of more and better fruit with a satisfactory spray program.

Acknowledgments

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NOTES ON THE ECOLOGY OF MAMMALS OF A STRIP-MINED AREA IN SOUTHERN ILLINOIS

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Where lands are progressively laid bare by strip-mining, observations of changes of habitat and responses of animals become possible on a scale not often available to ecologists and provide a ready means of obtaining data useful in understanding faunal distribution. Nevertheless the ecology of striplands has not been studied extensively. Often they are not within easy distance of interested students.

The revegetation of such areas in southern Illinois has been described by Bell (1956:85-91) and Brewer and Triner (1956:73-84), and that of other Illinois strip-mined areas by McDougall (1925:378) and Croxton (1928:158). The invertebrates of several selected communities were studied by Smith (1928:493). Yeager (1942: 619) recognized that invasion of striplands by mammals was related to the age of the areas since mining. Brewer (1958:544) found no significant correlation between the age of stripped area and species of birds breeding there. He believed that "local variation in vegetation may have been most important in determining density." In a study of the distribution of *Peromyscus leucopus* ssp. and *P. maniculatus bairdi*, Verts (1957:56) found that *P. leucopus* ssp. preferred older strip-mined areas and *P. m. bairdi* preferred more recently mined areas. In Ohio, Riley (1954:324) compared wildlife populations on strip-mined land with those on various types of agricultural land. Lewis and Peters (1955: 117-124) reported on the physicochemical characteristics of stripland ponds in southern Illinois.

As part of an investigation to determine the wildlife potential of coal strip-mined lands in southern Illinois, an ecological study of the mammalian fauna was conducted. The study was started August 4, 1954, and terminated May 30, 1956. Distribution and populations of mammals as related to the age of strip-mined areas, vegetative composition, and topography were aspects most intensively investigated.

Description of the Area

The 1,792-acre research area is located in Perry County, about 5 miles south of Pinckneyville and 2 miles west of Pyatts, Illinois. Southern Illinois University holds title to the western 920 acres, and the remaining 872 acres is owned by Truax-Traer Coal Company.

Strip-mining operations began on this land in 1932 and continued until 1950, with the exception of 1934. The study area, therefore, contains 18 areas which vary in age from 6 to 24 years. The acreage, direction of stripping, and shape of these tracts are not uniform. There are also several unmined areas which vary in size from 4 to 51 acres and total approximately 154 acres.

Topographic, soil, and vegetative characteristics of this area have been previously described (Verts, 1957: 53). In general, there were few

differences in vegetative composition between the oldest and the most recently mined areas. The only major difference in vegetative characteristics was an increase in diameter and height of trees corresponding to an increase in time elapsed since mining.

Materials and Methods

Techniques used in small-mammal censusing were as follows: 30 to 50 stations were established in lines at about 10-yard intervals and 2 museum-special or ordinary mouse traps, baited with a mixture of peanut butter, oatmeal, and DDT, were set within a 3-foot radius of each station marker. Traplines of this type were operated for two consecutive nights in a strip-mined area of each age in late summer and early autumn of 1954 and late winter and early spring of 1955.

Distribution and relative abundance of larger mammals were determined by observing sign (tracks, scats, cuttings, and dens) and individuals. As this area was open to public hunting and trapping, an index by use of questionnaires was made of numbers of game and fur mammals removed.

A representative collection of stripland mammals was desposited in the Cooperative Wildlife Research collection of Southern Illinois University.

Nomenclature of mammals used in this paper is that of Miller and Kellogg (1955).

Accounts of Species

Didelphis marsupialis Kerr. Opossum. Tracks and scats indicated relatively uniform distribution. In autumn of 1954, sign was found on almost every spoil pile, but by autumn of 1955 was much reduced. Three specimens collected; none by hunters and trappers.

Blarina brevicauda (Say). Short-tailed shrew. One taken in black locust plantation, strip-mined in 1939.

Cryptotis parva (Say). Least shrew. Skull found in area strip-mined in 1944.

Scalopus aquaticus (Linnaeus). Eastern mole. As indicated by extent of runways, found to be restricted usually to moist sites between spoil piles and in unmined areas. In periods of heavy precipitation, runways were more extensive and occasionally crossed crests of spoil piles. Two collected.

Pipistrellus subflavus (F. Cuvier). Eastern pipistrelle. Six shot near unmined woodlands on west edge of study area. Pipistrelles probably use area only to feed and drink; sites favored for roosting (Hamilton, 1943:86) relatively few.

Lasiurus borealis (Müller). Red bat. Five taken in same locality as pipistrelles. Probably feeds and drinks on area but roosts elsewhere.

Sylvilagus floridanus (J. A. Allen). Cottontail rabbit. Populations determined by counting groups of droppings (pellets) in 4- by 100- foot quadrats. Ten quadrats established in strip-mined areas of each age, with approximately equal numbers on spoil-crests, slopes, and in valleys. As indicated by mean number of piles of pellets per quadrat, cottontails occurred throughout area, but most abundantly in more recently mined areas, especially in tracts mined in 1947, 1948, and 1949.

Cottontail populations apparently not correlated with height, density, or composition of vegetation, except in dense pine plantations where sign was rarely observed.

Hunter-success reports indicated that 138 (0.74 per hunter-hour) and 141 (0.53 per hunter-hour) cottontails were harvested in the 1954-1955 and 1955-1956 hunting seasons, respectively. Pellet counts indicated a population decline of similar magnitude.

Marmota monax (Linnaeus). Woodchuck. Active dens observed in strip-mined areas of all ages. No apparent correlation between numbers of den sites and age of strip-mined areas. Concentrations of burrows in unshaded rocky areas supporting dense stands of sweet clover.

Tamias striatus (Linnaeus). Eastern chipmunk. Nine taken in autumn of

1954 near west edge of study area. Although all activity was noted within 50 yards of unmined woodlands, two animals had burrows in spoil piles. Repeated hunting and trapping in 1955 produced no chipmunks.

Sciurus carolinensis Gmelin. Gray squirrel. Individuals noted on several occasions on unmined portions of study area; it may be assumed that they ranged short distances into spoil piles. Lack of mature forest and mast-producing trees probably exclude this species.

Sciurus niger Linnaeus. Fox squirrel. None observed on striplands, but leaf nests containing fur of fox squirrels were found in areas strip-mined in 1932, 1933, 1943, and 1945, and in several unmined tracts. Low density of woodlands and lack of mast-producing trees probably limit this species.

Glaucomys volans (Linnaeus). Southern flying squirrel. Evidence was fur left in rat trap nailed to large tree near west edge of area. Limiting factors probably same as those listed for tree squirrels.

Castor canadensis Kuhl. Beaver. Cuttings indicate periodic use of some stripland ponds. Evidence of heavy beaver activity previous to this investigation was noted in one pond. A freshly cut cottonwood was found in small pond nearby in May, 1955, but repeated observations revealed no additional sign. An insufficient food supply probably limits this species.

Peromyscus leucopus (Rafinesque). White-footed mouse. Taken in strip-mined areas of all ages, this was predominate species of *Peromyscus* in older tracts, and was only *Peromyscus* taken in areas strip-mined in 1932, 1933, 1935, and 1939. Three hundred sixteen taken in 6,221 trap-nights from August, 1954, to May, 1955.

Peromyscus maniculatus (Wagner). Deer mouse. Taken in areas of all ages except those mined in 1932, 1933, 1935, and 1939. Predominate species of *Peromyscus* and attained highest population levels in more recently strip-mined areas (Verts, 1957:56). Four hundred twenty-seven taken in 6,221 trap-nights from August, 1954, to May, 1955.

Pedomys ochrogaster (Wagner). Prairie vole. Taken in all areas except those mined in 1937, 1938, 1939, 1941, 1942, and 1945. Usually associated with large areas of cheat and bluegrass, but, in winter, runways found beneath fallen sweet clover stems. Only 32 taken in 6,221 trap-nights; eight in 400 trap-nights in the area strip-mined in 1944.

Ondatra zibethicus (Linnaeus). Muskrat. Populations indexed by recording numbers of cuttings, den entrances, and scats in ponds easily accessible by boat. Activity noted in almost every pond of sufficient depth to retain water throughout year but was relatively more intense in smaller ponds.

Definite correlation noted between quantity of muskrat sign and character of shoreline soils. Little muskrat activity noted in ponds with high proportion of rock and shale to clay in their banks. Banks which facilitated tunneling apparently essential as water depth usually too great and aquatic vegetation too limited to allow construction of houses.

Trappers reported taking 7 and 102 muskrats in the 1954-1955 and 1955-1956 seasons, respectively. Improved reporting system in 1955-1956 season was undoubtedly responsible for most of difference between two years.

Mus musculus Linnaeus. House mouse. Seventeen taken in spring of 1955 in areas mined in 1940, 1943, 1947, 1949, and 1950. Habitat near water apparently preferred as most specimens taken within 25 yards of pond.

Canis latrans Say. Coyote. Similiarity between coyote and dog sign made study difficult, but tracks found in areas mined in 1932, 1933, 1947, and 1950 were believed those of coyotes. In December, 1954, adult female trapped in tract mined in 1950. Farmers and hunters reported two "wolves" nearby.

Vulpes fulva (Desmarest). Red fox. Tracks rarely observed, but when found, usually in the same locations as those of gray foxes. None seen, but skull found in area mined in 1932.

Urocyon cinereoargenteus (Schreber). Gray fox. Tracks found in strip-mined areas of all ages. In general, numbers of tracks observed greater in 1955 than in 1954. Increase attributed, in part, to additional roads on area, thus increasing opportunity to observe sign. Several gray foxes flushed, but none taken.

Procyon lotor (Linnaeus). Raccoon. As indicated by sign, raccoons more or less uniformly distributed, but greatest activity noted at edges of ponds and along roadsides. Apparently most raccoons were ground dwellers.

Trappers and hunters reported taking none in 1954-1955 season and 17 in 1955-1956 season. According to reports, night hunting with dogs not productive on

striplands as raccoons habitually entered ground dens. Two collected.

Mustela frenata Lichtenstein. Long-tailed weasel. Sign noted in areas strip-mined in 1932, 1933, and 1936 where temporary ponds were surrounded by heavy growths of sandbar willow. Tracks in snow in January, 1956, were especially numerous in area mined in 1932.

Mustela vison Schreber. Mink. Sign found near seven of larger ponds. In general, more sign was observed in autumn of 1954 than in 1955. Trappers reported taking two and five in 1954-1955 and 1955-1956 seasons, respectively.

Mephitis mephitis (Schreber). Striped skunk. Sign rarely observed in autumn 1954; believed that striplands did not provide suitable habitat. In summer of 1955 sign more abundant, and skunks commonly observed in early morning or late evening. Some seen in 1932, 1933, 1936, 1945, and 1946 strip-mined areas, and tracks were seen in all areas.

Odocoileus virginianus (Zimmermann). White-tailed deer. Except for one animal flushed in September, 1954, in area mined in 1932, no evidence of deer was noted. Residents near area reported observing deer on striplands.

Discussion

The mammalian fauna of the striplands may be divided into four ecological groups: 1) Species becoming established in older strip-mined area; 2) Species distributed throughout striplands; 3) Species which apparently invade striplands soon after mining and are absent or reduced in numbers in older strip-mined areas; and 4) Species whose distribution is dependent on special conditions prevailing in localized areas on striplands.

In the first group may be placed the short-tailed shrew, eastern pipistrelle, red bat, chipmunk, gray squirrel, fox squirrel, flying squirrel, white-footed mouse, long-tailed weasel, and white-tailed deer. These species may, in general, be classified as woodland forms, or at least associated with woodlands. Plantation-type tree plantings (except pine plantings) in some of the older strip-mined areas probably are materially aiding invasion by woodland species.

Mammals more or less uniformly distributed throughout the striplands are the opossum, cottontail rabbit, woodchuck, coyote, red fox, gray fox, raccoon, and striped skunk. Most of these can be found in a wide variety of habitats, and cannot be classified as species associated with preference for specific vegetative types. It is possible that the general uniformity of vegetative cover is responsible for wide distribution of these forms on the striplands.

The only mammal which apparently invades striplands soon after mining and then is eliminated by changes associated with increased age of strip-mined areas is the deer mouse. Undoubtedly, other species will exhibit this same tendency, but length of time since mining is not sufficient for many such changes to be evident.

Mammals limited in distribution by special factors are the eastern mole, beaver, prairie vole, muskrat, house mouse, and mink. Except for the prairie vole, quantity and presence of water are apparently limiting. This species was usually found in areas which supported heavy growths of grasses. The beaver, muskrat, and mink are predominately aquatic forms and were associated with permanent water. Within this special habitat, soil composition further limited the muskrat. The house mouse and eastern mole tended to be associated with moist soils.

These ecological groups, except the latter one, appear to be seral stages in a succession toward a forest type fauna. Although there were no measurable differences in species composition of the vegetation which could be interpreted as succession toward a forest climax, slight changes in light intensity, relative humidity, temperature, wind velocity, and surface litter due to greater height and canopy size of trees in older strip-mined areas may have been sufficient to initiate changes in faunal distribution. Herbaceous composition will probably show greater responses in the future to the physical changes caused by greater height and canopy size of trees.

Summary

Mammals of a southern Illinois strip-mined area were studied with emphasis on factors which limit distribution of various species on such lands. The area contained 18 tracts mined in various years from 1932 to 1950, excluding 1934.

The only observable major difference in vegetation was increased height and diameter of trees on older strip-mined areas. Species composition or number of stems of herbaceous vegetation were not significantly different between areas of different age.

Evidence of 26 species of mammals was found on the area.

Stripland mammals were divided into four ecological groups: those becoming established on older strip-mined land, those established on more recently mined land but absent or scarce in older areas, species distributed throughout the area, and species limited by some special factor to a localized habitat.

Changes in the physical conditions due to increased height and canopy-size of trees may be sufficient to initiate changes in mammal distribution.

Acknowledgments

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APPLIED SCIENCE AND THE CLASSICS—FULL CIRCLE IN A CENTURY

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In Illinois a century ago, research in applied science—research formalized to the extent of being recorded in print—was just getting under way. The time was one of rapidly expanding agriculture, hordes of hungry insects, and distressed and vocal farmers. Because this research came in answer to the needs of the time, most of it was biological.

Making known the results of scientific research was then, as now, a major problem. Of the few technical journals then in existence in North America, most were published on the distant Atlantic seaboard.

Organization of the Illinois State Agricultural Society in 1853 and the Illinois State Horticultural Society in 1856 opened to Illinois biologists of the mid-nineteenth century two important publication outlets. The transactions of these societies carried many well-written papers based on careful observation, experiment, and study. Subjects of papers included the origin and character of prairie soils; birds of Illinois most interesting to the agriculturist; strawberry culture on the prairies; cultivation, use, and value of the osage orange hedge; tree culture on the prairies; and the education of farmers' daughters.

Founding of the Illinois Natural History Society in 1858 gave biologists of the state still other opportunities for making known results of their research. At annual meetings of the society, well-conceived papers on biology were read, and most of them were later published.

Previous to 1853, the *Prairie Farmer*, founded in Chicago 12 years earlier, was the principal publication outlet for Illinois biologists. Although this periodical was frankly slanted toward the practical tiller of the soil, it regularly published technical reports by well-trained, even though largely self-trained, scientists. The high quality of these reports was in contrast to the character of some of the articles by farmer-readers with less exacting standards of research; in those days every farmer was his own agricultural experiment station.

Prominent among Illinois biologists of mid-nineteenth century—men who stressed the application of science—were John A. Kennicott, a physician, school teacher, and horticulturist; William Le Baron, physician, ornithologist, and entomologist; Cyrus Thomas, lawyer, preacher, teacher, mammalogist, and entomologist; Jonathan Baldwin Turner, college professor, horticulturist, and espouser of causes; Benjamin Dann Walsh, classical scholar, farmer, lumberman, and entomologist.

Applied biological research of the time took mainly two courses: 1) propagation of varieties of plants adaptable to the prairie soils; and 2) attempts to reduce the numbers of insects that with frustrating regularity ruined the crops.

With the opening of the Illinois country to settlement had come travelers or pioneer residents interested

in naming the plants and animals. Although interest in systematics continued, by 1860 the emphasis in most biological research had become principally utilitarian.

Many individuals contributed to this change. In response to needs of the time, they shifted the emphasis to life history studies that had direct bearing on the control of noxious insects, to the breeding and culture of plants, and to other studies that promised to make life pleasanter on the prairies. They employed trial and error techniques that by present standards would be considered clumsy and crude. However, they were scrupulous observers and prodigious workers who had no fear of new ideas. Among their written records are to be found scientific concepts that seem modern even today.

For example, they were aware that catastrophic environmental changes may be caused by man. Nearly 100 years ago, Walsh (1861:339) wrote: "Now it is universally the case, that whenever man, by his artificial arrangements, violates great natural laws, unless by some artificial means he can restore the overturned balance, he pays the penalty affixed to his offense."

Illinois biologists of a century ago were aware that man possesses possibilities of controlling nature through nature—that injurious insects can be controlled by natural agents, not only by birds but by other insects. Walsh (1861:340-341) advised his readers that "one of the most effective means of controlling noxious insects is to be found in the artificial propagation of such cannibal species as are naturally designed to prey on them," and that, so far as he was aware, "cannibal insects have never yet been bred for utilitarian purposes, yet it is by no means an uncommon practice to collect such as are found at large in the woods and fields, and apply them to subdue some particular insect that is annoying us."

The mid-century effort to make science practical, to bring it to the level of people who could make immediate use of it, was not an isolated movement. It abetted and was abetted by the crusade for industrial education. A number of individuals active in one cause were involved in, or at least sympathetic toward, the other. Jonathan Baldwin Turner, dedicated leader of the industrial education movement, was a prominent member of the State Horticultural Society and first President of the Illinois Natural History Society.

In a long letter addressed to a committee representing farmers who had heard him speak at Granville, Illinois, in November, 1851, Turner outlined his plan for industrial education. Of its background he wrote (Turner, 1855:369-370): "All civilized society is, necessarily, divided into two distinct co-operative, not antagonistic classes — a small class, whose proper business it is to teach the true principles of religion, law, medicine, science, art and literature; and a much larger class, who are engaged in some form of labor in agriculture, commerce, and the arts. For the sake of convenience, we will designate the former the PROFESSIONAL, and the latter the INDUSTRIAL class; not implying that each may not be equally industrious— the

one in their intellectual, the other in their industrial pursuits.''

Turner maintained that the colleges and universities of his time were designed for the professional class and he advocated the establishment of institutions of higher learning specifically adapted to the education of mechanics and farmers—the 95% of the population he thought might be included in the industrial class.

In a pamphlet entitled *The Industrial League of Illinois* (Carriel, 1911 : 115-119), Turner asked, ''Can, then, no schools and no literature, suited to the peculiar wants of the industrial classes, be created by the application of science to their pursuits? Has God so made the world that peculiar schools, peculiar applications of science, and a peculiar resultant literature are found indispensable to the highest success in the art of killing men, in all states, while nothing of the kind can be based on the infinitely multifarious arts and processes of feeding, clothing, and housing them?''

He lectured and lobbied ceaselessly, until his friend Abraham Lincoln in 1862 signed the Morrill Act that provided for land grant colleges—and then until the Illinois Industrial University at Urbana, now the University of Illinois, was chartered in 1867.

In agreement with Turner in the effort to make scientific learning available to the masses, Walsh (1868 : 9), as the first State Entomologist of Illinois, wrote that his annual report for 1867 was ''intended chiefly for the use of common folks.''

Walsh (1868 : 10) wrote further, ''If there is one thing which I have at heart more than another, it is to popularize Science—to bring her down from the awkward high stilts on which she is ordinarily paraded before the world—to show how sweet and attractive she is when the frozen crust, in which she is usually enveloped, is thawed away by the warm breath of Nature—and more especially to demonstrate how delightful that particular branch of science [entomology], to which I have devoted half a life-time, may be to any one, who will keep his eyes wide open as he walks through his garden or his orchard.''

Paradoxically, some of the most influential leaders in the industrial education movement, the effort to popularize science, and the new emphasis on applied biology had received classical educations.

Le Baron, second State Entomologist of Illinois, had been graduated from Harvard Medical College, where the classics were required subjects. Turner had taken prizes in English composition and Greek while a student at Yale College and had taught Latin and Greek at Illinois College, Jacksonville. Walsh, an Englishman, had been educated at Cambridge University, from which he had received a master's degree. As a classical scholar, he had published a work on the comedies of Aristophanes in 1837, the year before he moved to a farm in Illinois.

Probably these men could not have foreseen that, in their zeal to make science and other learning available to all, they had started a movement that too often has resulted in a type of education tending to be both narrow and shallow. Today, a century after J. B. Turner pleaded the

cause of industrial or vocational education, university and industrial leaders are taking a new look at the training of scientists.

We may doubt whether Turner would have approved of the industrial type of education many scientists now receive, for at one time he specifically included scientists in the professional class.

Pressure for a more liberal education for both scientists and engineers is coming today from many directions.

In a speech delivered in April, 1955, before the Phi Beta Kappa Association of the Chicago area, Lloyd Morey, then President of the University of Illinois, cited the results of a business survey reported in the April, 1953, issue of *Fortune* magazine; the conclusion was that overspecialization is robbing business of potential top management material. President Morey (1955: 10) added his own conclusion, that vocational education "has been accorded too significant a place in college and university programs." He said: "I do not mean to suggest that we should not teach law to the lawyers, or engineering to the engineers, or accounting to the accountants. But I would like to make them all *educated people* and not merely *technicians*."

Grayson Kirk (1959:18), President of Columbia University, wrote recently, "In the college curriculum, the task must be that of continuing for the science-motivated student his long-range interest in his field while giving him enough of a broad educational base on which to build his professional specialization."

Henry T. Heald (1957:179), President of the Ford Foundation, in addressing a group of engineers in New York City, declared, "Scientists and engineers, no less than doctors, lawyers, or the managers of industrial enterprise, need to stand as intelligent, liberally educated men, regarding their knowledge not as a narrow, isolated specialty but as a particularized competence which they, in their general wisdom, can share with the rest of society."

Nathan M. Pusey (1958:69), President of Harvard University, befor a University of California audience at Berkeley, pleaded for an acceptance by the public of "the fact that learning is apt to be most useful, even within professional schools, when it does not aim too intently or too directly at the goal of immediate utility."

Massachusetts Institute of Technology in 1953 established a department of humanities as a recognition of the need for liberal studies in a technological institution.

The Wenner-Gren Foundation, in setting up conditions for pre-doctoral fellowships in anthropology, apparently has tried to assure that students who receive grants will be well-rounded scientists. The Foundation recommends that the applicant for a grant "have a prior degree in some discipline other than anthropology, or be planning to secure such a degree, or its equivalent, in the course of his studies, and be a graduate of some institution other than the one nominating him for a Pre-Doctoral Fellowship."

In a word, the pressure from higher education and industry today is for scientists with the breadth of interests of Turner, Walsh, Le Baron, Kennicott, and Thomas.

We have now come full circle in

the education of scientists. Pressure is beginning to be felt for scientists educated as Turner, Walsh, and other early Illinois scientists had been educated—in the classics.

Werner Heisenberg (1958 : 60-63), German winner of the 1932 Nobel Prize for Physics, related that as a student he improved his understanding of atomic theory through his reading, in the original Greek, of one of Plato's dialogs and he paid tribute to the influence of Greek thought upon his own thinking. Those who "wish to get to the root of things in their chosen vocation," he stated, "whether it be in technology or medicine, are bound sooner or later to encounter the sources of antiquity, and their own work can only benefit if they have learnt from the Greeks how to discipline their thoughts and how to pose questions of principle."

The plea for the classics in the education of scientists comes not alone from a theoretical physicist. It comes from — of all places — industry. T. R. Henn (1958 :1325-1326), member of the faculty and an administrative officer of St. Catharine's College at Cambridge University, wrote, "Great industrial firms appear to find that, while the supply of *competent* technologists is adequate for their purposes, the supply of men for the very top posts —men who know enough science to direct research, yet whose concern is mainly with wider issues and problems of the highest magnitude —is relatively poor. Many of these firms find it profitable to select arts men — preferably, and strangely, classicists—and train them for such posts. A world-famous electrical firm has just taken seven men with first-class degrees in classics and is converting them, by an intensive three-year course, into physicists and mathematicians."

What is the explanation of this long unsuspected but now beginning-to-be-appreciated relationship between the classics and science—even applied science? Perhaps it is that scientific research— research that is to be imaginative, dynamic, and of the highest order—should be based on the postulate that man gets a longer view of Earth from Venus than he gets from Earth.

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RETAIL TRADE IN A DISPERSED CITY

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Introduction

Early work in the field of central place theory by Christaller (1933) suggested an idealized pattern of urban settlements regularly spaced in a nested hierarchy and surrounded by hexagonal tributary areas. Since that time, many other students have demonstrated the existence of a hierarchy in various parts of Europe and North America. More recently, Berry and Garrison (1958b) have shown that the concept of a threshold and the range of a good can be used to liberate theory from assumptions about even distribution of population and purchasing power over uniform topography.

It does not necessarily follow, however, that an urban hierarchy always exists. It may be, for example, that as accessibility increases, the normal hierarchy collapses and is replaced by some modified pattern. Alternatively, the hierarchy may not have an opportunity in which to develop.

Purpose

The politically discrete cities of southern Illinois have been previously referred to as a dispersed city by Beimfohr (1953), although the urbanized areas are separated in some cases by tracts of agricultural land. It is the purpose of this paper to present some aspects of the retail trade of the area and to test the hypothesis that the area functions as a single city, rather than as a number of discrete cities. From this it will be inferred that spatial propinquity is a factor tending to prevent the emergence of hierarchical patterns. The study will also try to cast some light on the nature of dispersed urban agglomerations with respect to retail trade, and to suggest a way in which these may be expected to differ from strongly nucleated urban areas.

Definitions

On the basis of traffic flow and population density the area was delimited along county lines, and includes Perry, Franklin, Jackson, and Williamson counties (Fig. 1). Within these counties lies the urban core, which is composed of 14 major centers ranging in population size from more than 11,000 to less than 2,000 persons. It is these centers which would normally be expected to be arranged in a hierarchy, but, as will be seen shortly, they are not so arranged.

Beyond this urban core lies a less densely populated area, forming a situation which is taken to correspond to that of a city surrounded by its metropolitan county area. The structure of this city (as defined in Fig. 1) includes 14 major retail shopping centers located in the scattered urban centers, none of which is clearly dominant over the remainder. One important distinction between this city and another city of comparable size is therefore immediately apparent. There is no equivalent of a "downtown" shopping district.

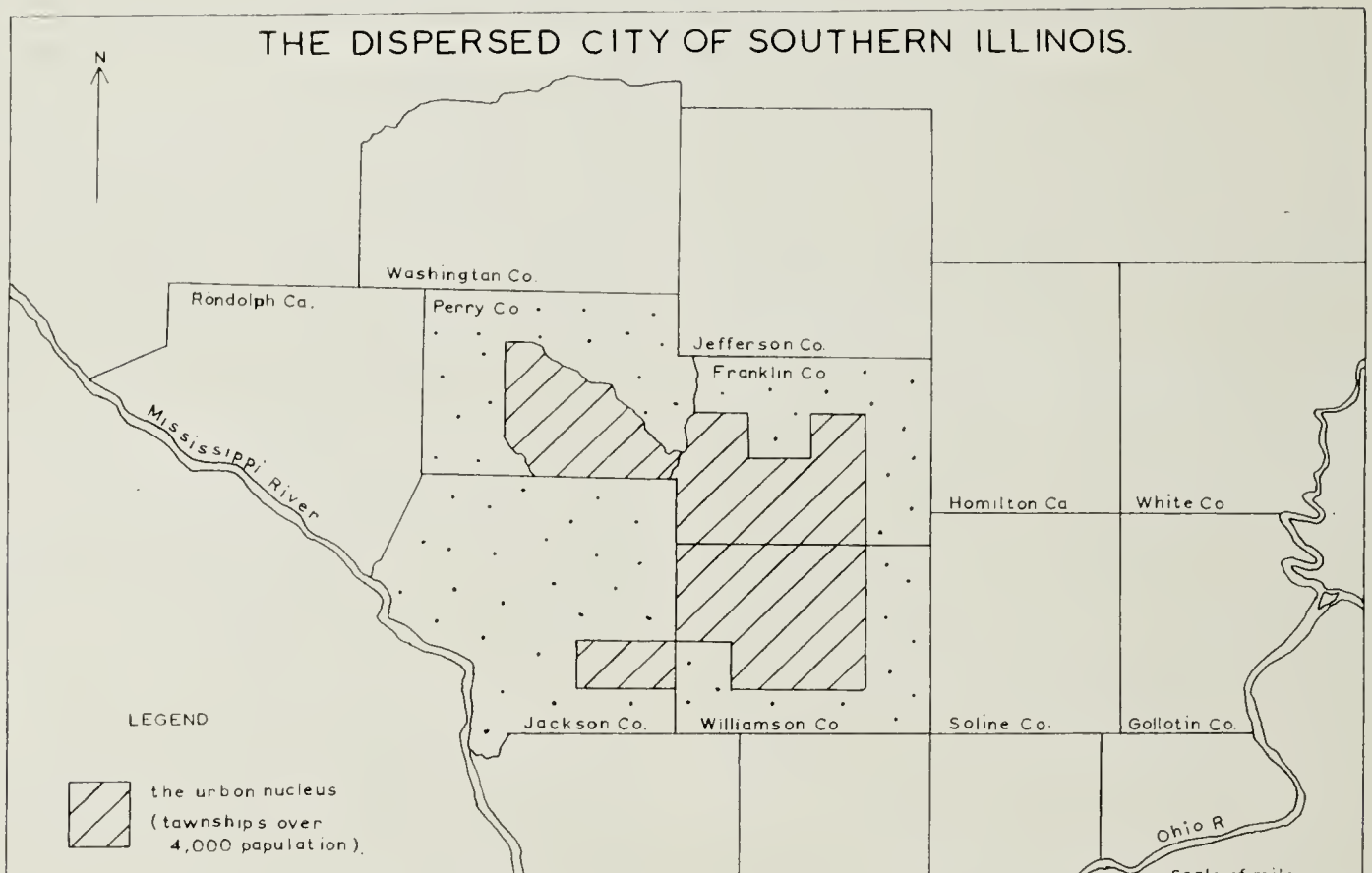

Figure 1.

The Rank-Size Rule

The unity of the dispersed city of southern Illinois is indicated by application of the Zipf rank-size rule, which has been shown to be generally valid for areas within the United States (for example, the state of Washington), as well as for the whole country. When the dispersed city of southern Illinois is placed in the rank-size curve for Illinois, a closer approximation to the ideal curve results.

Retail Trade per Capita

On the basis of previously formulated central place theory, it is known that smaller cities attract more trade from beyond their own limits, in relation to their size, than is the case in larger cities. This is one aspect of the variation of the basic-nonbasic ratio. It is to be expected therefore that, if the dispersed city of southern Illinois operates as a single city, it will have a relatively low value of retail trade per capita in common with cities of its size class. Data collected for 1955 (Sales Management) for the 30 cities in the United States of most similar size to the total population of the dispersed city, 157,000, (the 15 next smaller and the 15 next larger) demonstrate that in fact the dispersed city has an even lower value of retail trade per capita than all except three of those cities, and that it falls just within two standard deviations below the mean of their distribution.

As a confirmation of this information, the dispersed city was compared with five other cities, also created synthetically, this time by the cumu-

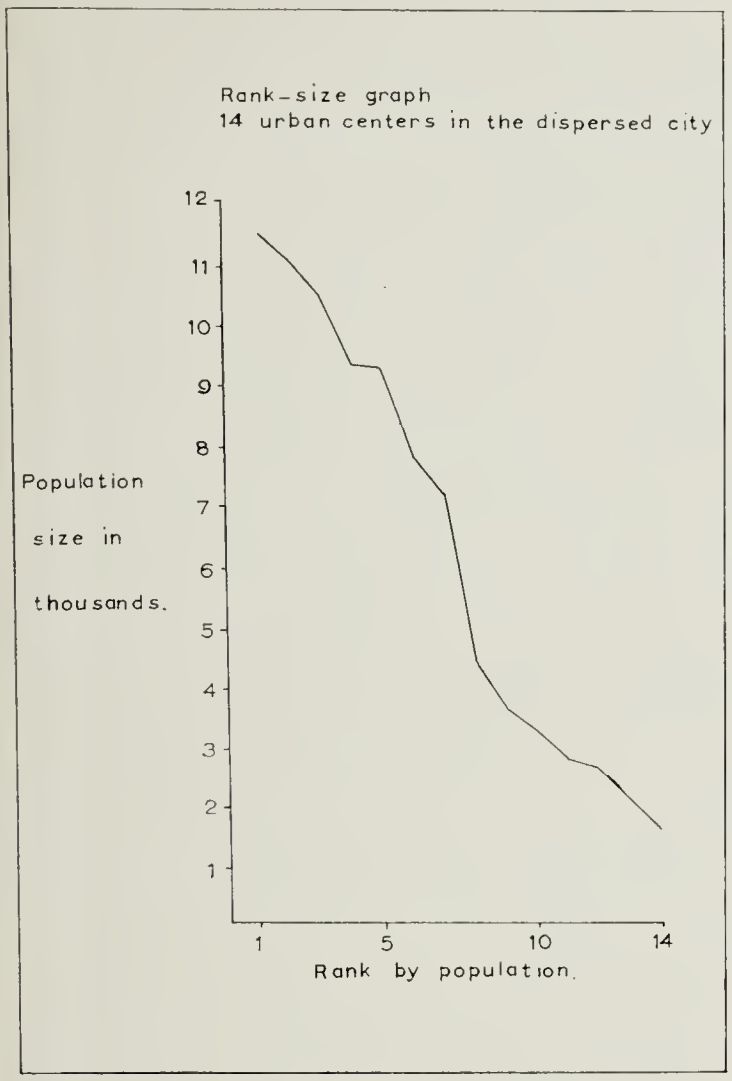

Figure 2.

lation of repetitive random samples from all cities in each synthetic city. The values of retail trade per capita, in this case, are much higher than the values for the dispersed city, which lies well outside two standard deviations from the mean of their distribution. This confirms that the cumulation of data for the southern Illinois centers, into one figure for a single dispersed city, is unlikely to have revealed by chance such low retail trade values per capita.

Percentage Sales Index

Certain assumptions involved in the fore-going paragraph, however, are not strictly valid. For example, the purchasing power of all persons is not equal, and secondly, given equal purchasing power varying amounts will be spent on retail purchases. An attempt in the direction of meeting the first objection is to consider the relationship of retail sales volume to effective buying income (E. B. I.). By calculating the former as a percentage of the latter, an index is obtained which is partly a measure of the amount of income spent on retail purchases and partly a measure of purchases made by non-residents and, therefore, of centrality.

When the index for the dispersed city is compared with the distribution of values for the 30 cities of similar size referred to above, it falls within one standard deviation of the mean, again suggesting a confirmation of the characteristics of a single large city. The second objection remains valid, that percentage of income spent on retail purchases varies from person to person and

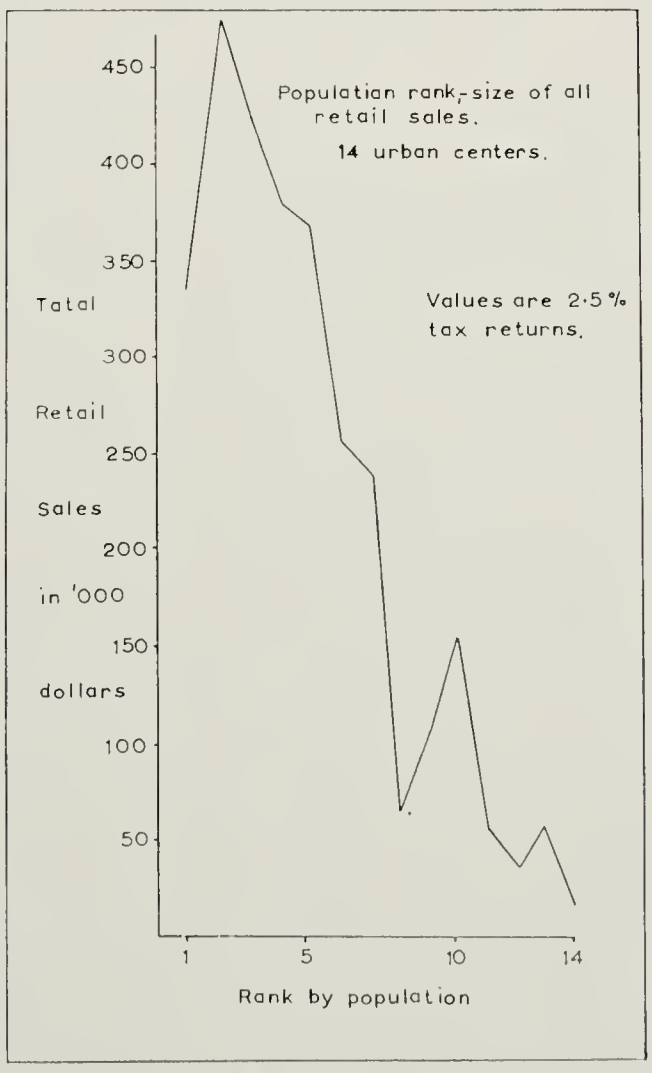

Figure 3.

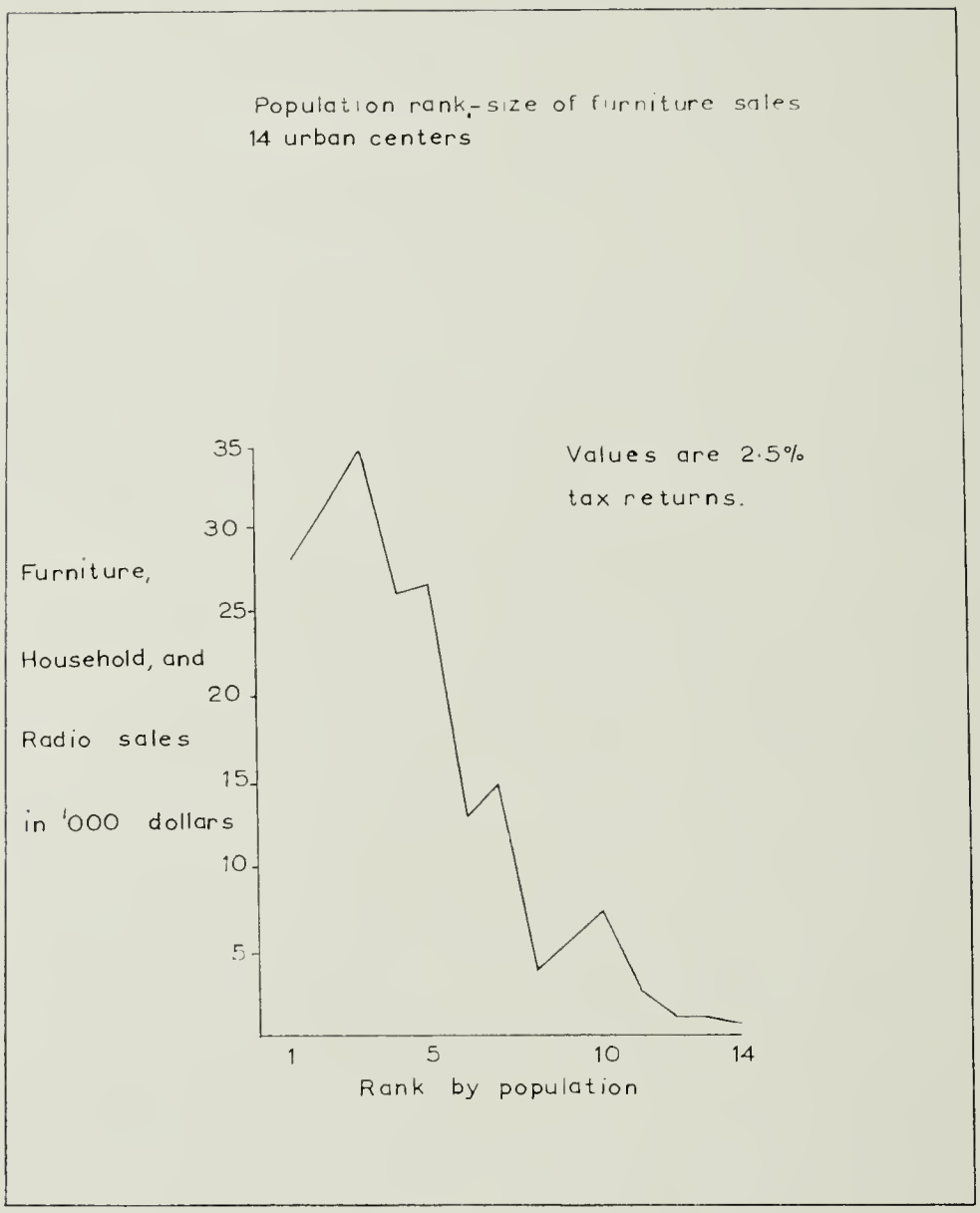

Figure 4.

from place to place. This factor is minimized by a comparison with all 66 cities of similar E. B. I. (E. B. I. of the dispered city is $193 million; similar E. B. I. is defined as ranging from $150 million to $250 million), on the assumption that expenditure on retail purchases will vary much less in each income group. The dispersed city is found to exhibit an index close to the mean of this group.

In conclusion it may be stated that evidence concerning the overall pattern of retail sales in this area has been gathered and compared against data for other cities. The results do not disprove the hypothesis that the discrete cities of southern Illinois may be regarded as a single dispersed city.

Internal Trade Patterns

It is now reasonable to question if the pattern of retail trade within the dispersed city corroborates data already discussed. The population rank-size graph for the 14 largest urban centers within the dispersed city (Fig. 2) assumes remarkably different form when population is replaced by value of retail sales. The second, third, fourth, and fifth urban centers in population rank all have a larger value of trade than the first center, West Frankfort (Fig. 3). The latter center, on the other hand, does have larger sales of furniture, household and radio goods than centers four and five (Fig. 4). Sales of general merchandise show an even more unusual pattern (Fig.

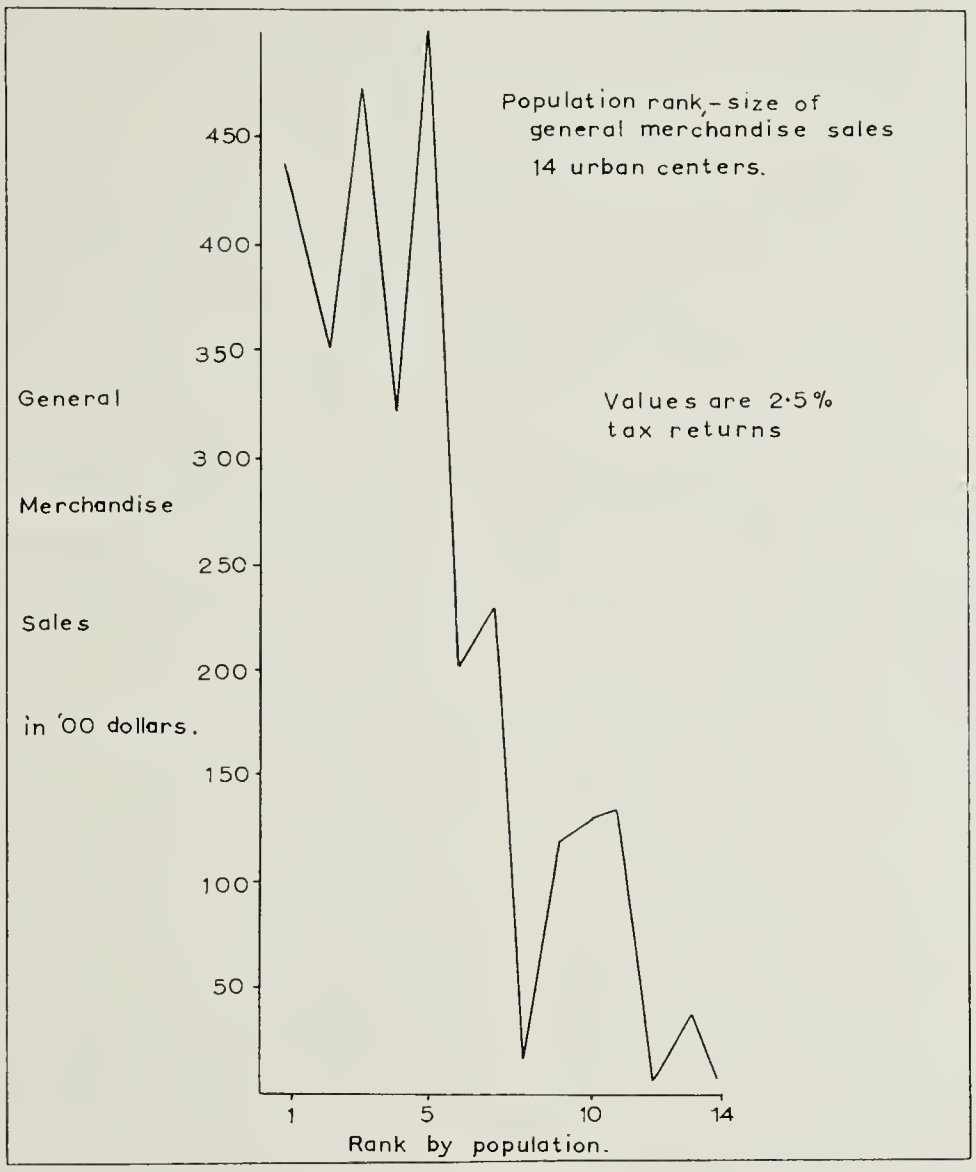

Figure 5.

5), centers two and four being much lower than centers one, three, and five. This evidence points strongly to a marked degree of local specialization in various types of retail trade among the different centers.

It seems clear that from the view point of retail trade these urban centers are not arranged in a hierarchical pattern, possibly because their very proximity to each other in an area of some 157,000 people has served to encourage local specialization rather than the domination of any one of them.

External Trade Patterns

The foregoing conclusions raise the question of the importance of a highly concentrated "downtown" shopping district. Information gathered in the dispersed city suggests that local specialization among the various centers does not completely replace the attraction of downtown shopping districts. For example, a study, by the Trades and Services Committee (1957), made in West Frankfort, the largest of the urban centers in the dispersed city, indicated that of a random sample of inhabitants interviewed 68% reported habitual purchases outside of West Frankfort. Of these, 81% reported the "outside place" to be another urban center in southern Illinois, thus demonstrating a general willingness to travel within the dispersed city to shop, a conclusion which might well have been predicted on the basis of the above anal-

ysis. It is interesting to note that the remaining 18.5% reported habitual purchases outside southern Illinois, these being distributed as follows:

St. Louis	14.1%
Chicago	2.5%
Evansville	1.9%

On the reasonable assumption that 18.5% is an unusually high figure for habitual purchases outside the city of residence, we may conclude that this dispersed city loses some of its trade to outside competitors by virtue of its lack of the equivalent of a "downtown" shopping center.

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USE OF WORLD HEALTH ORGANIZATION MOSQUITO TEST KITS WITH DDT RESISTANT DROSOPHILA

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Introduction

Widespread use of commercial insecticides in the last two decades has enhanced the development of resistance to chlorinated hydrocarbon insecticides by some important disease vectors and by a number of arthropods which are of importance to public health (Brown, 1958). In connection with this problem, the World Health Organization (W.H.O.) has undertaken the task of coordinating international research in the study of resistance to insecticides. This organization also provides a kit for investigating the resistance of mosquitoes. It also provides all the materials and instructions necessary to carry out a testing program.

The initial problem of insecticide-resistance is the determination of its existence. Probably the best method is by use of a standardized testing procedure with standardized equipment and conditions. One of the goals of the W.H.O. is to develop such a standardized test for comparison of susceptibility and resistance levels of arthropods used for genetic study. Thus, one part of this study dealt with the investigation of the value of the W.H.O. test kit as a standardized testing device for DDT resistant *Drosophila*.

Materials and Methods

Eight strains of *D. melanogaster* were used for these tests. HL 1 - Q and HL 2 - Q were representatives of sibling-selected lines with high DDT-resistance cultured by Bennett (1959). LL 1 - Q and LL 2 - P were low DDT-resistant lines selected during that same period. Cage 1, duplicate, used in this study, was descended from the original unselected wild-type progenitors of both the high and low resistant lines (Bennett, 1959). SySM 1 and ORS 1001 were DDT-resistant strains selected by King (1957) at the Cold Spring Harbor Biological Laboratory. Brown-Eye-R was a strain of DDT-resistant flies which were selected by Crow (1954) at the University of Wisconsin. It should be pointed out that a varying amount of time had elapsed between the time that these flies were originally selected for DDT-resistance and the time that the tests for this study were conducted.

The first resistance testing in this study was done in January and February, 1959, using the W.H.O. dieldrin sets. The flies were etherized and sorted to isolate females for testing purposes. One test for one stock used flies from several cultures. The use of female *D. melanogaster* tends to give more reproduceable results than those based on males (Crow, 1954). Range in age was from 24 hours to one week in most cases. This method gave results which were based on the average aged fly and probably added a greater degree of variation than would results based on flies of a specific age.

Testing methods for either the W.H.O. dieldrin or DDT sets followed this general pattern:

1. Flies of a particular stock were collected from food vials and/or bottles 12 to 24 hours prior to testing, etherized, sorted, and 25 to 30 females transferred to holding vials (this follows the recommendations for adult mosquitoes per the W.H.O. instruction booklet (W.H.O., n.d.). It was later found that this number could be increased without distorting the results.
2. Flies were incubated for a 12- to 24-hour recovery period to reduce any effects caused by etherization, which might have subsequently influenced their reaction to DDT or dieldrin.
3. The following day live, healthy flies were transferred to tubes containing insecticide for the test. During actual exposure the flies were kept in the incubator, to maintain constant conditions as closely as possible, for 1, 8, or 18 hours depending on the time required for the individual test.
4. Upon completion of exposure to insecticide, flies were returned to holding vials marked to indicate the concentration of insecticide to which the flies had been subjected. Flies were placed in and removed from the testing tubes in a serial order so that the first in were the first out. This procedure insured equal test periods.
5. Flies were returned to the incubator for a 24-hour "recovery" period. The live and dead flies were counted (flies unable to walk being considered dead), and the results recorded.

The methods used with Bennett's (1959) test sets (an alternate testing method) which were made up in June, 1958, follow closely the overall pattern used for the W.H.O. 18-hour testing program. Bennett's test sets were originally made by impregnating filter paper with acetone as the vehicle for DDT. The acetone evaporated, leaving pure DDT crystals on the paper.

In our tests, concentrations of insecticides were used which were regular multiples of the lowest concentration. This was done to make it possible to use "Karber's Method" (Cornfield and Mantel, 1950) to estimate the dose of insecticides which would kill one half of the flies represented in the population of each series of three or more concentrations (LD50).

The LD50 values for individual sets of concentrations were treated as units of data in the statistical analysis.

Results and Discussion

Dieldrin Tests.—The resistance of the strains of *D. melanogaster* to dieldrin (one hour W.H.O. test) was similar with only minor variations to the relative degree of resistance these same stocks displayed for DDT at 18 hours' exposure in Bennett's 1955-1957 study (Bennett, 1959). The stocks resistant to DDT in his study appeared resistant to dieldrin in this study, and those stocks susceptible to DDT also showed susceptibility to dieldrin. The control, Cage 1, retained a mean that was located between those of the resistant and susceptible stocks. Although these data could indicate cross-resistance of these flies to DDT and dieldrin, this phenomenon of a species being resistant to the two insecticides is not necessarily an expected result (Brown, 1958). Analysis of the results using the F test (Pearson and Bennett, 1942) indicated very little significant difference between the means of HL 1-Q and LL 1-Q flies or flies in Cage 1. By this same method of analysis, ORS-1001 showed a significant difference in its reaction to dieldrin when compared to flies in either LL 1 or Cage 1. This indicated that ORS was definitely more resistant to dieldrin

TABLE 1.—Comparison of 18-hour 0.25% DDT resistance and control testing with World Health Organization's test kits (based on percent flies killed).

Test concentration	HL 1-Q	HL 2-Q	ORS-1001	Brown-eye-R	All stocks combined
Control (oil)	100.0	100.0	27.8	100.0	.....
0.25% DDT	88.0	70.8	18.7	90.0	.....
Control (oil)	34.4	92.6	60.6	97.5	.....
0.25% DDT	33.8	50.0	57.4	89.7	.....
Control (oil)	90.5	51.7	90.0	97.7	.....
0.25% DDT	32.4	35.6	65.6	95.3	.....
Control (oil)	63.7	90.8	91.7	.....	.....
0.25% DDT	41.7	86.3	77.3	.....	.....
Average of control	75.6	85.8	61.9	98.7	81.2
Average of 0.25% DDT	49.4	62.2	57.8	90.9	66.1
Ratio· $\frac{\%\text{ kill control}}{\%\text{ kill 0.25\% DDT}}$	1.532	1.379	1.071	1.086	1.227
Probability observed differences due to chance (x^2 method)	<0.001	<0.001	<0.001	$0.2>P>0.1$	.....

than were either of the susceptible lines or the control line.

DDT Tests.—Preliminary tests of one-hour duration were conducted using the W.H.O. DDT test papers. These tests produced no appreciable kill at any concentration, thus rendering them worthless as a test of DDT resistance. The instruction booklet recommends that an increase in exposure times should be the next step in such an instance. An increase to a 2-, a 4-, and if necessary to an 8-hour exposure was prescribed, but since the flies had been selected with 18-hour DDT exposures, the testing program was increased directly to 8 hours.

Results of the eight-hour W.H.O. DDT tests showed that LL 1 - Q, a susceptible stock, was most resistant. HL 1 - Q, a resistant strain, proved to be the most susceptible of all. The control, Cage 1, showed the same general range as most of the resistant stocks. Analysis (F test) of the results indicated that there were significant differences, at the 1% level, between the means for HL-1 and Cage-1 and also HL-2 and LL-1. However, some flies survived the eight-hour test at the 4.0% DDT level, so a longer exposure seemed desirable.

The 18-hour W.H.O. tests of DDT resistance produced a shifting of the relative order of the strains as to resistance, with the exception of ORS-1001 which remained fairly constant. There was a lower degree of significance in these 18-hour tests, which might have been due to the number of tests rather than to the number of flies tested. Differences between stocks tested at 8 and 18 hours were all significant

with the exception of HL 1-Q. This was unexpected because HL-1 showed the greatest resistance of all tested stocks at 18 hours and the least at 8 hours. This can be accounted for by the assumption that either there was a large genetic variation within members of this stock since resistance is determined by genetic control (Brown, 1958), or that different exposure times produced different results for the same stock. If the latter is true, and it does seem possible, the W.H.O. test kits, in order to be a standardized test device for *Drosophila,* should specify a certain period of time. This time limit could be established only after a large number of data from other research had been collected and analyzed.

A comparison was made of the 18-hour W.H.O. DDT test, the 18-hour Bennett DDT test, and an 18-hour test made by Bennett during the summer of 1958 at the University of Wisconsin. The Bennett sets used in this study were constructed and used in June, 1958. Therefore, it would be logical to assume that the test sets were more potent then than for this study, due to the volatilization of the DDT in the eight-month interim. The median lethal dose was significantly higher for the same stocks in the earlier testing program (plus some other minor variations), than it was in the tests we conducted. This would indicate a possible change in resistance between the testing dates. It is also possible that change in resistance was correlated with change from banana to cornmeal agar food. It is also possible that the conditions Bennett maintained in 1958 were enough different from the conditions in this study to cause varying results, even though the former conditions were the pattern for our testing program. Both sets of test data obtained with Bennett's test sets were vastly different from the W.H.O. test results for 18 hours, enough so that the question arises as to what stocks should be compared for relative susceptibility and resistance. Again, a greater number of tests should be conducted before this matter can be settled.

One feature is very apparent in the final analysis of the 18-hour W.H.O. DDT tests. Table 1 shows that the control paper which was impregnated with mineral oil alone produced a greater kill of *D. melanogaster* than did any test at a 0.25% DDT concentration, conducted at the same time with the same strain of flies. This difference was very significant in three of the four stocks and was prevalent in all controlled tests. Survival for the 18-hour W.H.O. test was low enough that it did not warrant testing the susceptible lines. The high percentage of kill appeared to be the result both of DDT and of the mineral oil. The oil definitely took the role of a poison or toxic substance rather than that of a neutral agent in the control experiments. We assume that there was also some effect from the oil used with the DDT, this would distort the data on the number killed by DDT alone. We feel this fact renders the W.H.O. test kit ineffective as a standardized device at 18 hours, for *Drosophila,* because it measures two different results at the same time with no discrimination. Although mineral oil did not

appear lethal in our tests at 1 or 8 hours, its effect was outstanding at 18 hours.

It is possible that HL-1 and HL-2 were resistant to DDT by behavior, in that they could recognize DDT and avoid it. Assuming this, it would then seem likely that they were unable to recognize the mineral oil as being potentially lethal, and thus did not avoid it in the control tubes. But in the 0.25% DDT tubes they may have recognized DDT and thus avoided both. This testing equipment would be improved by using a better solvent, such as acetone, which evaporates readily.

Fluctuations in temperature and humidity were occurring during the tests, and undoubtedly affected the results (Brown, 1958), although an attempt was made to regulate them. With the equipment available such errors were expected and must be considered when reviewing the results.

Acknowledgments

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Summary

1. A number of DDT resistant and susceptible strains of *Drosophila melanogaster* were tested for resistance to DDT and dieldrin, using the W.H.O. mosquito test kits. The same strains were also tested for DDT resistance by a method designed for *Drosophila*.

2. DDT and dieldrin resistance appeared to be correlated, suggesting some kind of cross reaction.

3. Apparent DDT resistance, as evidenced by ranked order of the strains, changed markedly with exposure time.

4. The mineral oil used as a carrier of insecticide in the W.H.O. test kits proved highly toxic in the 18-hour exposure tests with DDT.

5. The mosquito test kits in their present form are not suitable for use with *D. melanogaster*.

6. The most valuable aspect of the kits, for use with *D. melanogaster*, lies in the provision of standardized insecticide impregnated papers for use in equipment available locally.

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Charles W. Otto and H. Neil Hardy
Lincoln-Way Community High School, New Lenox

The Idea

The Phi-Chem Association is a junior-senior science club established at Lincoln-Way Community High School to promote interest and activities in science. During the past five years scientists from the Joliet area have conducted science classes, provided programs for club meetings, served as judges for science open houses, provided consultation and materials for individual student projects, served as resource persons for career selection, and conducted special field trips for selected groups of students.

At the Annual Lincoln-Way Science Open House, Phi-Chem Association members are expected to exhibit a scientific project and are encouraged to use originality in their preparation. In working with original investigations, students often enter areas in which the instructor's knowledge and experience are limited. Limited library facilities and inadequate material resources available to the students create additional problems.

Each year, as the project work improves, these problems become more acute and the need for skilled outside assistance becomes more apparent. The Board of Directors of the Association discussed the problem and considered methods of securing assistance. Suggestions considered for obtaining material resources included purchases by the school, club activities to raise funds, support from the Future Scientists of America Foundation, and industrial support. Acquiring additional library materials through better utilization of the United States Patent Office, the College of St. Francis Library, the John Crerar Library in Chicago, and industrial libraries in the local area were discussed at length. In discussing the need for professional consultation, the Board carefully considered the type of persons needed, the individuals in the area who would be interest and available, and how their assistance might be secured.

Over a period of time, a plan evolved in which the Board of Directors selected a group of students interested in research. After the students were selected, the problems present in the students' projects and the Board of Directors' suggested solutions to these problems were presented to an industrial scientist. He accepted the plan with enthusiasm and immediately steps were taken to put it into operation.

Selection of Participants

Superior senior members of the Association were invited to submit applications to participate in the group research program provided they were preparing for a career in science and were willing to use school time and evenings for consultation and investigation. Preliminary selection of 10 applicants was made by the Board of Directors and by H.

Neil Hardy, the Association's Sponsor.

Applicants were evaluated according to: interest in such a program; reasons for wanting to participate; interest in science as indicated by hobbies; previous science and mathematics courses studied; and work experiences. Other information, such as special achievements and honors, their agreement to give regularly of time in and out of school, and recommendations of employers and teachers were carefully weighed.

Final selection of six students and the arrangement of these into workable groups were made by Mr. Hardy. Final selection was based on students' plans for future scientific careers, interest in scientific endeavor, and ability to cooperate and work with others. The six participants were placed in teams of three. The club sponsor asked each of the participants to list in order of preference the three members of the group with whom they would most like to work. With this information and personality traits observed in school activities, assignments were made.

Industrial Consultant

The Board felt that the industrial consultant should have experience working with students, a genuine interest in students and teaching, a background in chemical research, experience as a leader or director of a research group, and time and help he could and would give in consultation.

The Board was unanimous in its approval of Dr. J. V. Karabinos as a consultant. As Director of Organic Research at Blockson Chemical Company, a division of Olin-Mathieson Chemical Corporation, he had given his assistance to the Association's activities on numerous occasions. Serving as Chairman of the Chemistry Section of the Illinois State Academy of Science, as a senior research consultant at the College of St. Francis, and a consultant for the production department of Olin-Mathieson Chemical Corporation provided him with a broad background for dealing with the diverse problems always present in student projects.

Dr. Karabinos entered into the plan with enthusiasm and was responsible to a large extent for the program's success.

Preliminary Planning

All Association members knew they were expected to complete and exhibit a project during the school year, and each team first concerned itself with a group problem rather than ones for individual students. The Association's sponsor discussed possible areas of investigation with the students and with Dr. Karabinos.

At the first session with the research consultant, the areas of interest were discussed and evaluated. Many new and important related ideas concerning scientific investigation were introduced to the students. Dr. Karabinos met with each group and gave participants an opportunity to ask questions and to express their current interests in investigation.

Within a week, each of the groups selected a tentative problem and began a literature search in the libraries at Lincoln-Way and College

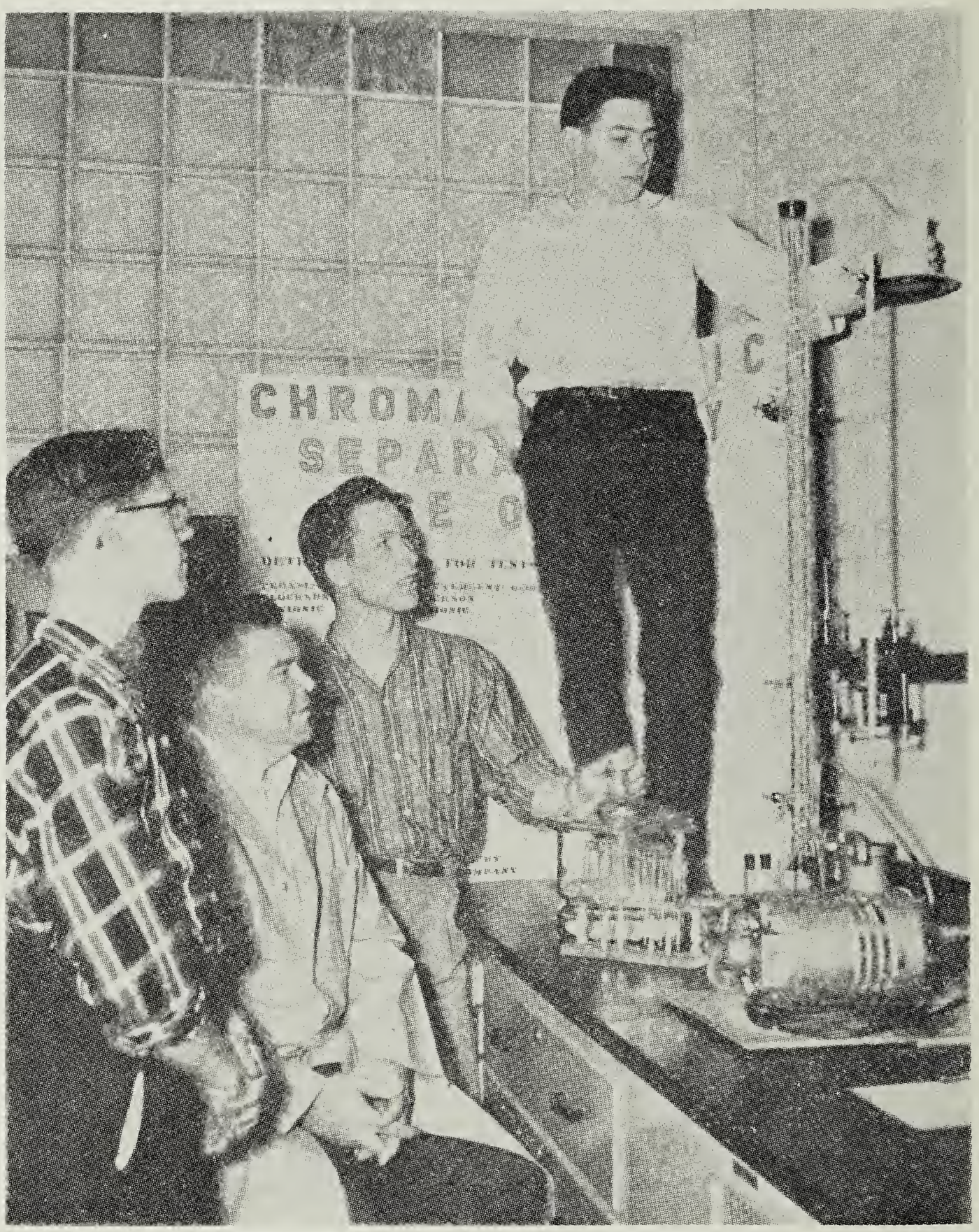
Lee Yunker, a member of the Phi-Chem Association's research group at Lincoln-Way High School, questions Dr. Karabinos concerning the isolation of rare earths as Wayne Klasing and Bob Hughes look on.

of St. Francis. One team finally selected the isolation of the rare earths, and the other selected separation of substances by the use of detergent foam.

Consultation and Materials

A consultation meeting was arranged by the sponsor for Saturday morning, ten days after the first session. The groups met in the library of Blockson Chemical Company where, with the assistance of the librarian, they became acquainted with scientific journals and other sources of scientific information. Numerous scientists, who were working in the laboratory that morning and had an interest in the fields being investigated by the groups, stopped by the library to talk with the students and to give suggestions concerning sources of information and methods of proceeding.

After the library session, Dr. Karabinos met with each of the groups and discussed their current problems in relation to information, procedures, and materials. Blockson opened its library to the students and offered to secure photostats of any pertinent article in the literature. Dr. Karabinos provided adequate quantities of rare earth carbonates, rare earth oxides, and one type of ion exchange resin. He secured six different types of deter-



Charles Otto, James Landfried, and Burke Lanham, members of the Phi-Chem Association's research group at Lincoln-Way High School, confer with Dr. Karabinos concerning the separation of compounds by the use of detergent foam.

gents and prepared a glass column for the group working with the separation by the use of detergent foam.

The students frequently returned to the library at Blockson and consulted with Dr. Karabinos on Saturday mornings or over the telephone when problems developed. The group working with rare earths visited the Lindsay Chemical Division of the American Potash and Chemical Corporation at West Chicago to secure additional information on procedures. They were

given a quantity of rare earth sulfates and ethylenediaminetetraacetic acid to use as an eludent. Several scientists at the local Science Open House offered ideas and suggestions. One scientist from Armour and Company sent materials on mineral flotation to the group working on separation by detergent foam and arranged for them to meet and consult with the director of the Armour Research Laboratory in Chicago. This interest and assistance on the part of professional scientists added impetus to the student investigations.

Interpretations and Suggestions

Late in April, the group working with rare earths felt it had succeeded in separating seven of the individual elements and the group working with detergent foam and foam separation had some very interesting data. Problems of interpretation of data and technical procedures multiplied rapidly, and the student groups asked for a conference with Dr. Karabinos. He came to school to meet with them; he observed procedures, results obtained, and made suggestions concerning procedures and treatment of data.

The group working with the separation of rare earths had questions concerning the use of eludents, the relative use and value of various ion exchange resins, and procedures and methods for placing cations on the resin columns. Although they had several well-defined curves on their graph, they were not certain that they had actually separated the individual rare earths.

The investigation on foam had resulted in some very interesting data, but the interpretation was difficult. Samples of foam taken from the top of a column containing a mixture of detergent and water with air passing through contained varying amounts of detergent. In fact, a graph of their results approached a normal fractional distillation curve. Additional problems in the separation of compounds by foam were encountered when chemical reactions occurred between detergents and the materials being separated.

Following this evaluation and suggestion session, students returned to their investigations with zeal and enthusiasm; they saw new questions and new ways of finding the answers.

Reactions of Student Participants

Student enthusiasm for and interest in the program was high from the day it was announced. Charles Otto, President, and Mr. Hardy, Sponsor of the Association, were besieged from the time the first applications were received until the final selection of six participants was made. These six students allowed no one to rest until they had their consultation with Dr. Karabinos and their problems selected. Every day at least one of the six would inquire if the laboratory would be open for the students that evening or over the weekend, and whenever it was open, several members of the group were present and working. The participants' willingness, and even urgent desire, to spend extra time in the laboratory showed a great amount of interest.

The members of both teams were eager to discuss their work with students, scientists, and interested

adults. They asked to present reports at Phi-Chem Association meetings, and they prepared papers for presentation at the local conference symposium and at the state meeting of the Illinois Junior Academy of Science. Both teams exhibited their work at the local Open House, district and state meetings of the Illinois Junior Academy of Science, conference science symposium, and a local meeting of the Lions of Lincoln-Way. Probably the best indication of their interest was their willingness to take time at any hour of the day or evening to explain their work to visitors to the science department. This interest was certainly gratifying to the school administration, to the Board of Directors of Lincoln-Way Community High School, to the staff members, and to outside visitors.

Perhaps from a scientific point of view, the greater understanding they developed of scientists and the scientific approach was the most valuable result. They exhibited this new interest and understanding whenever they had an opportunity to visit with research scientists. Participants were eager to know what problems the scientist was working on, how he was collecting and treating his data. Certainly there was developed a greater appreciation of the methods of research.

This development in the participating students had related effects on the students in the science department and, to a limited extent, on the total school population.

Reactions of Science Students

The reactions of science students in the department indicated additional prestige for the department and the participants, and a better understanding of scientists and their work. Initial interest was shown by the large number of students who completed application forms. This initial interest continued throughout the project, as was amply shown by the students' attentive interest during progress reports in Association meetings and by the many individuals who stopped by the laboratory to check on the progress the groups were making. Students, in general, were interested in the visits of Dr. Karabinos and in hearing suggestions and criticisms which he made. Probably this interest was partly due to the prestige he gave the department by coming and spending half-days with the students.

Through the reports in Association meetings and individual observations, most of the science students at Lincoln-Way became better acquainted with scientific research, its problems, and its operations. They now have a better idea of the time consumed in research and a knowledge of the pleasure derived from securing significant results.

Reactions of Scientists

The student investigation plan was enthusiastically endorsed by all who came in contact with it. Dr. Karabinos was appreciative of the opportunity to work with the students, and from the first discussion of the idea through the investigation period, gave time and effort toward its success. Whenever students telephoned or visited Blockson, he gave them unlimited assistance. On other occasions, he telephoned the school

to inquire how they were progressing. His discussions with the Association's sponsor have indicated satisfaction with the success of the endeavor.

Judges and scientists at the annual Science Open House took special note of these exhibits and offered special assistance and suggestions. Several of these offers of assistance included time and money on the part of individual scientists. Their comments following the judging were enthusiastic, and they were eager to see this type of program increase in scope and number. During the state meeting, graduate students stopped to visit and returned later with their professors to show them the work that high-school students were doing. These visits resulted in several invitations to the laboratories on the Champaign-Urbana campus of the University of Illinois.

The sponsor has gained additional knowledge and has enjoyed working with the program. From a teacher's viewpoint, it was a pleasure to see student interest develop and increase throughout the investigations. The interest of students and adult visitors in the program was most gratifying. The sponsor would again help initiate and encourage a similar program.

Summary

A high-school research plan is discussed; an industrial specialist and a teacher cooperatively work with high-school students to guide their selection of a problem and to assist them in securing information and materials. The investigation adds prestige among the total school population, to the science department, and to the science students who participated. The participants and observers are enthusiastic about the plan and feel it could be used effectively in other situations.

Manuscript received September 7, 1959.

FILMS RECOMMENDED FOR INSTRUCTIONAL PURPOSES

MILTON D. THOMPSON, *Chairman*
Educational Films Evaluation Committee, Illinois State Academy of Science

1. ANIMALS—WAYS THEY MOVE (EB) 10 min., sound and color, three star[2], p-i-j.[1]

   A colorful and interesting demonstration of animal locomotion, including swimming, crawling, hopping, running, walking, climbing, flying, etc.

   Reviewer: M. D. Thompson.

2. ANIMALS—WAYS THEY EAT (EB) 11 min., sound and color, four star[2], p-i-j.[1]

   A very elementary and interesting study of the manner of feeding of higher vertebrates, especially birds and mammals. Shows diverse types as bills of birds, grinding teeth of cows, tearing teeth of lions, noses of pigs and elephants, and many others. Excellent close-up photography.

   Reviewer: M. D. Thompson.

The Audio-Visual Center at the University of Indiana is distributing three films on microorganisms. They are excellent for high-school biology and for hygiene and health education in college, but are felt to be too elementary for college bacteriology. The educational collaborators are: Walter A. Konetzka and Leland S. McClung. The films are:

3. BACTERIA—LABORATORY STUDY (U. Indiana) 15 min., sound and color, three star[2], h-c′.

   Deals with bacteriological procedures such as sterilizing, culturing, staining, and examinations. Suggests some techniques for examination.

   Reviewers: M. D. Thompson and J. M. Sanders.

4. MICRO-ORGANISMS — HARMFUL ACTIVITIES (U. Indiana), 15 min., sound and color, three star[2], h-c′.

   Deals with diseases of people, plants, animals, and with food spoilage. It points out such factors as refrigeration, food preservation, public health measures, and community health with references to viruses, toxins, antitoxins, general immunity, phagocytosis, antibodies, and Koch's postulates. The film may create some wrong impressions concerning such diverse subjects as tuberculosis and chemical food preservatives due to over simplification.

   Reviewers: M. D. Thompson and J. M. Sanders.

5. MICRO-ORGANISIMS — BENEFICIAL ACTIVITIES (U. Indiana), 15 min., sound and color, three star[2], j-h-c.[1]

   Designed primarily for those who have not had a background of micro-biology, it presents quite simply, but effectively, subjects such as decay, enzymes, metabolism, the nitrogen cycle, antibiotics, yeasts, alcohol, acetic acid, silage, and the carbon cycle.

   Reviewers: M. D. Thompson and J. M. Sanders.

6. BASIC NATURE OF SEXUAL REPRODUCTION (U. Indiana), 15 min., sound and color, four star[2], h-c′.

A classroom film of quality, illustrating the similarity of sexual reproduction in plants and animals, both as to the nature of gametes (size, shape, mobility difference, as between male and female), and the sex organs of plants. In animals, ascaris slides are used to show fertilization, and meiosis is shown by models and movable chromosomes. The film seems better suited to the study of plant morphology than to genetics. Diction of the narrator is not always clear, and a knowledge of the terminology is assumed.

Reviewers: M. D. Thompson, J. M. Sanders, and Elnore Stoldt.

7. CHAMELEON (International Film Bureau), 6 min., sound and color, three star[2], i-j-c-a.[1]

Prepared under supervision of New York Zoological Society. Elementary but extremely interesting. Demonstrates color adaptability and suggests some of the factors that effect it, such as light, heat, and emotions. Illustrates how chameleons climb and walk, peculiar foot adaptation, prehensile tail, independent eye movements, and the use of the tongue in capturing insect food.

Reviewer: M. D. Thompson.

8. CHANGING CLIMATES (Pictura), 11 min., sound and color, three star[2], i-j-h.[1]

A striking film on Alaskan glaciation. Shows how something of the climates of the past can be interpreted from a study of glaciers and their work. Elementary, nontechnical science.

Reviewers: M. D. Thompson and C. Condit.

9. CRUSTACEANS (EB), 15 min., sound and color, three star[2], j-h-c-a.[1]

Interesting colorful film on lobsters, barnacles, shrimps, and their relatives. Carefully prepared text, excellent photography, good selection of representative groups, and a high interest level.

Reviewers: M. D. Thompson and P. W. Parmalee.

10. ERUPTION OF KILAUEA (U. S. Geol. Survey), 11 min., sound and color, three star[2], j-h-c-a-Aud.

Documentary film of the 1955 eruption of Kilauea. For the first time in Hawaii, and probably anywhere, scientists were able to observe and photograph at close range the entire sequence of the development of volcanic events. Having been warned by hundreds of earthquakes, the photographers were able to cover the eruption from the first opening of fissures in the ground, appearance of lava, formation of cones, and flows, firework displays of lava fountains and great pillars of billowing steam as a lava river reaches the sea. Recorded by volcanologist Gordon A. MacDonald, Director of the U.S.G.S. Hawaiian Volcano Observatory, as a scientific record. It is not in

the usual educational film format. The vocabulary in places is somewhat technical.

Reviewers: M. D. Thompson and C. Condit.

11. EXPLORING RY SATELLITE (Delta Film Productions, Inc.), 28 min., sound and color, four star[2], j-h-c-a.
Most interesting and informative. Interesting and detailed information on the Explorer Satellite, showing its fabrication, instrumentation, assembly, manner in which it records and transmits data back to earth, and tabulation of data. Shows with considerable detail the assembly of the rocket mechanism, fueling, firing, and tracking. Achieves drama and suspense.

Reviewers: M. D. Thompson and C. Condit.

[1] Recommended for: p—primary; i—intermediate; j—junior high; h—high school; c — college; a — adult; Aud.—Auditorium.

[2] Very best films (one or two per year) are rated as five-star films. A three-star film is good, accurate and suitable but does not have the outstanding features, interest and technique of the best films.

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1959-1960

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EXHIBITS ASSISTANT & AWARDS CHAIRMAN: William L. Downes, University Illinois, Urbana.

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BANQUET: Zane B. Carothers, University Illinois, Urbana.

WESTINGHOUSE TALENT SEARCH: L. R. Heckard, University Illinois, Urbana.

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ANTHROPOLOGY and/or ARCHAEOLOGY: Elaine Bluhm, 137 Davenport Hall, University Illinois, Urbana.

ASTRONOMY: R. P. VanZandt, 1100 N. Parkside Drive, Peoria.

BOTANY: Miss Alene Ruyle, Carlinville High School, Carlinville.

CHEMISTRY: Vaughn Armer, Oak Park-River Forest High School, Oak Park.

CLUB ACTIVITIES: Milton D. Thompson. Illinois State Museum, Springfield.

CONSERVATION: Robert L. Smith, DeKalb High School, DeKalb.

GEOLOGY and/or GEOGRAPHY: Roger Brown, University High School, Urbana.

MATHEMATICS: Sister Crescentia, College of St. Francis, Joliet.

METEOROLOGY: Glen E. Stout, American Meteorological Society, 101 Elmwood Road, Champaign.

PHOTOGRAPHY: John Ronketto, Jr., Canton Sr. High School, Canton.

PHYSICS: Charles Foreman, Maine Township High School, Park Ridge.

RADIO: V. F. Hershey, Illinois Bell Telephone Co., 625 S. 6th St., Springfield.

ZOOLOGY: Thomas Wilson, Evanston Township High School, 1600 Dodge, Evanston.

District Chairmen and District Meetings

NORTH SUBURBAN:

Steve Kubisen, Glenbrook High School, Northbrook.
Guenther Kolb, Evanston High School, Evanston.
April 9—Evanston High School

SOUTH SUBURBAN:

Donald Hopkins, Carl Sandburg High School, Orland Park.
Joe Gross, J. Sterling Morton High School, Cicero.
Henry Krass, Downers Grove High School, Downers Grove.
April 9—Illinois Institute of Technology

NORTHERN:

Kenneth Harmet, Northern Illinois University, DeKalb.
Herbert Tischler, Northern Illinois University, DeKalb.
Edwin Shykind, Northern Illinois University, DeKalb.
April 2—Northern Illinois University

NORTHWESTERN:

John Ronketto, Jr., Canton Sr. High School, Canton.
Bill Vasen, Canton Jr. High School, Canton.
Maurice Kellogg, Western Illinois University, Macomb.
William Crall, Western Illinois University, Macomb.
Herbert Priestley, Knox College, Galesburg.
April 9—Canton Senior High School

CENTRAL:

Harvy Jackson, Illinois State Normal University, Normal.
Tom Edwards, Illinois State Normal University, Normal.
Kermit Laidig, Illinois State Normal University, Normal.
April 9—Illinois State Normal University

SOUTHWESTERN:

Felix H. Lauter, Illinois College, Jacksonville.
April 9—Illinois College

SOUTHEASTERN:

Miss Ica Marks, Eastern Illinois University, Charleston.
A. J. Hoffman, Eastern Illinois University, Charleston.
April 23—Eastern Illinois University

SOUTHERN:

Willard M. Gersbacher, Southern Illinois University, Carbondale.
Otto Ohmart, Anna Jonesboro High School, Anna.
Miss June Balding, Nashville Community High School, Nashville.
April 2—Southern Illinois University

CHICAGO PUBLIC SCHOOLS:

Edward Schwachtgen, Bureau of Curriculum Development, 228 N. LaSalle St., Chicago.
April 7-10—Museum of Science and Industry.

CHICAGO AREA CATHOLIC:

Sister Mary Ivo, Immaculata High School, 640 Irving Park Road, Chicago.
Brother Stoehr, St. Leo High School, 901 W. 79th St., Chicago.
April 23—DePaul University

STATE MEETING:

May 6 and 7, 1960, University of Illinois, Urbana.

THE EDITOR'S PASSPORT

"The Editor stood 'fore the Heavenly Gate,
His features pinched and cold.

He bowed before the Man of Fate,
Seeking admission to the fold.

'What have you done?' St. Peter asked,
'To gain admission here?'

'I was the Journal's editor, Sir,
For many a weary year.'

The Pearly Gates swung open wide
As Peter pressed the bell.

'Come in and choose your harp,' he cried;
'You've had your share of Hell!' "

Journal of the Irish Medical Association

EDITORIAL NOTE

It would be impossible to thank all those who have aided me in the editing of the *Transactions* during the last five years. I am especially grateful to the members of the Editorial Board and others who have helped evaluate manuscripts submitted. Particular credit should go to the authors for their patient understanding of the necessities of financial and chronological factors.

Many changes have been made in the *Transactions*. I hope the majority were improvements.

I should like to ask that the cooperation received by me be extended to the new editor, Dr. Paul Silva, Department of Botany, University of Illinois, Urbana.

HARVEY I. FISHER

PREPARATION OF MANUSCRIPTS FOR THE TRANSACTIONS

For publication in the *Transactions*, articles must present significant material that has not been published elsewhere. Review articles are excepted from this provision, as are brief quotations necessary to consider new material or varying concepts. All manuscripts must be typewritten, double spaced, with at least one-inch margins. The original copy, not the carbon copy, is to be submitted.

Titles should be brief and informative. The address or institutional connection of the author appears just below the author's name. Subtitles or center headings should be used; ordinarily one uses subtitles such as *Introduction, Acknowledgments, Materials, Methods, Results, Discussion, Summary,* and *Literature Cited.* All papers should have a summary.

No footnotes are to be used.

The section entitled *Literature Cited* must include all references mentioned in text. It is not to include any other titles. No references to the literature are to be placed in footnotes. Citations under *Literature Cited* are as shown below:

Doe, John H. 1951. The life cycle of a land snail. Conchol., 26(3): 21-32, 2 tables, 3 figs.

Doe, John H. 1951. Mineralogy of Lower Tertiary deposits. New York, McGraw-Hill Book Co., iv + 396 pp.

Quoted passages, titles, and citations must be checked and rechecked for accuracy. Citations to particular pages in text are Doe (1908:21-36) or (Doe, 1908:21-36); general citation in text is Doe (1908) or (Doe, 1908).

Tabular information should be kept at a minimum. Tables should not be more than one page in length. Do not duplicate tabular data in text. Headings for tables and columns should be brief. Reduce to the barest essentials, or preferably omit, explanatory notes on tables. Each table and its heading should be on a single page; do not place any table on the same page with text.

Photographs should be hard, glossy prints of good contrast. Graphs, maps and other figures reproduce best when prepared for at least one-half reduction; lettering, numerals, etc. on all figures in a manuscript should be worked out to proper size for such reduction. Line widths, letter size etc. should be uniform from figure to figure within a published paper. Figures should be drawn on good quality white paper or on drawing board. Use only India ink. Use a lettering device (Leroy or Wrico) for numerals and words; do not print "free-hand."

Legends for photographs and figures should be brief; type them on a separate sheet of paper. Indicate figure number and your name on back of illustration; do not write with pencil on the backs of photographs.

Authors will receive galley proofs; these should be read carefully and checked against the original manuscript. Reprints may be ordered at the time galley proofs are returned to the Editor:

HARVEY I. FISHER,
Department of Zoology,
Southern Illinois University,
Carbondale, Illinois.

ILLINOIS
Land of Lincoln